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ABSTRACT

A study was undertaken to provide information on the overall structure of the engineering workforce in Australia and the job functions of each occupational cluster. In the study, the term "engineering technical workforce" was defined as all staff primarily performing engineering functions between the levels of tradesperson and professional engineer or surveyor. The study involved a review of literature, interviews with Technical and Further Education and Training Authority staff and engineering workers, and two national surveys that obtained data from more than 2,000 persons throughout Australia. Data were analyzed through cluster analysis. Ninety-nine primary clusters were identified; these merged into intermediate clusters and then four major clusters: engineering systems and administration, civil engineering and surveying, drafting and design, and electrical and electronic engineering. The job function profile and background characteristics of each occupational cluster were drawn. The study found that the duties important to most workers were written communication, oral communication, general administration, the use of calculators and computers, and engineering drawing. The study showed that there are two primary levels of technical engineering workers: associates and technicians, with associates having completed more education and technicians having more on-the-job training. Recommendations for changes to course organization and content were made as a result of the study. (KC)

TAFE

TAFE NATIONAL CENTRE FOR
RESEARCH AND DEVELOPMENT

OCCUPATIONAL CLUSTERS OF THE ENGINEERING TECHNICAL WORKFORCE

GEOFF HAYTON

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The wealth of information provided by the more than 2,000 people who responded in the surveys is acknowledged.

ABBREVIATIONS

ABS	Australian Bureau of Statistics
AIEA	Australian Institute of Engineering Associates
ASCO	Australian Standard Classification of Occupations
CAD	Computer Aided Drafting
CAE	College of advanced education
CAM	Computer Aided Manufacturing
CIM	Computer Integrated Manufacture
CODAP	Comprehensive Occupational Data Analysis Programs
DEIR	Department of Employment and Industrial Relations
DTAFE NSW	Department of Technical and Further Education, New South Wales
EITB	Engineering Industry Training Board (U.K.)
ERIC	Educational Resources Information Centre
IEA	Institution of Engineers, Australia
NC	Numerical Control
NEC	Not Elsewhere Classified (ABS abbreviation)
OAI	Occupational Analysis Inventory
TAFE	Technical and Further Education
TDDEV	TAFE Division, Department of Education of Victoria
UNESCO	United Nations Educational Scientific and Cultural Organisation

CHAPTER ONE: SUMMARY

1.1 OVERVIEW

The TAFE National Centre for Research and Development undertook this major study of the engineering technical workforce in order to provide information on:

- the overall structure of the engineering technical workforce, including relationships between occupations in each branch of engineering and between each level;

- the job functions of each occupational cluster and other characteristics that would be of use to TAFE and other education and training bodies.

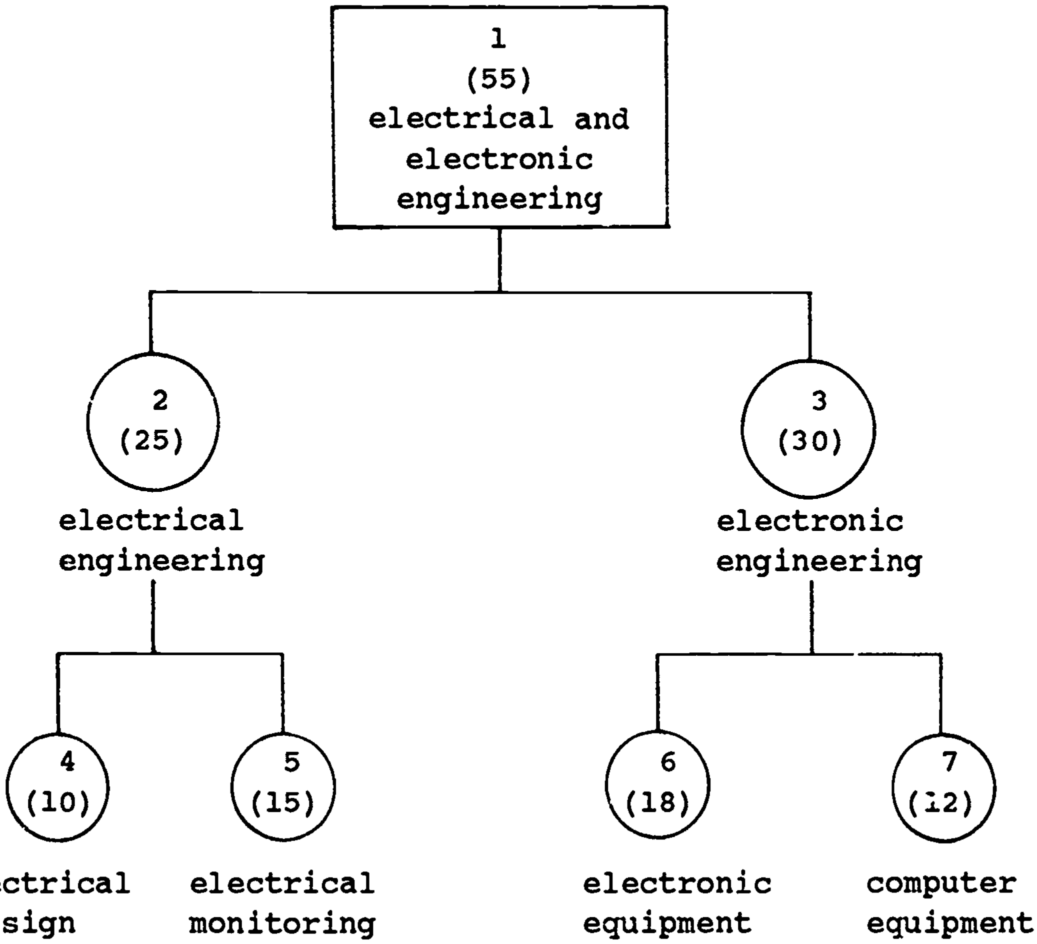
In the study the term engineering technical workforce was defined as the group that includes all staff primarily performing engineering functions between the levels of tradesperson and professional engineer or surveyor.

The study was the only one of its kind in Australia that was concerned with the full spectrum of engineering technical workforce occupations Australia-wide. This broad scope enabled an assessment of which skills may be required across a wide range of occupations and which are more specialised. It also enabled information to be obtained on the relationships between the various occupational clusters.

The study involved a review of relevant literature, interviews with TAFE and Training Authority staff and engineering technical workers, and two national surveys. The first national survey obtained a net sample of 1089 government and industry organisations and 1090 TAFE and CAE students and ex-students in all States and Territories. This survey aimed both to determine the names of those willing to participate in the second survey, and to collect broad information on the numbers in each occupational level and branch of engineering. The second survey obtained a net sample of 1230 engineering technical workers in all States and Territories. It aimed to determine the background characteristics and detailed job functions of each person.

The method of analysis of the data from the second survey was critical to the whole study. The main method used was cluster analysis. Cluster analysis sorts, by a statistical rather than a judgemental process, the respondents into clusters, the members of each cluster having similar job functions. The outcome of a cluster analysis is represented by a <u>cluster diagram</u>, which shows all the resulting clusters and the links between the clusters. The job function profile and background characteristics of each occupational cluster may also be determined and presented in tabular form.

A simple cluster diagram may look like the hypothetical example below:



In this example, the number at the top of each box or circle identifies the cluster number. The numbers in parentheses refer to the number of people in each cluster. The lines indicate the links between clusters. Each cluster linked by a line to a cluster above it is a subset of the upper cluster. For example, the 10 people in electrical design joined with the 15 people in electrical monitoring to form a single cluster titled electrical engineering, with 25 people.

The cluster analysis in this study was successful, and resulted in 99 small clusters, termed primary clusters, which were identifiable and clearly interpreted. The hierarchical pattern of the clusters was also meaningful and easy to interpret. Except for a few 'outliers', the primary clusters merged into a number of meaningful intermediate clusters, and these further merged into four major clusters. For example, the intermediate cluster of *electrical engineering* merged with the intermediate cluster of *electronic engineering* to form the major cluster of *electrical and electronic engineering*. The four major clusters were given titles as follows:

- engineering systems and administration (438 respondents);
- civil engineering and surveying (318 respondents);
- drafting and design (123 respondents);
- electrical and electronic engineering (188 respondents).

Figure 1.1 shows the hierarchical pattern of the cluster analysis, though only the larger clusters are shown because of limited space (the full diagram is given in Chapter 6 of the full report).

The job function profile and background characteristics (including average age, salary, highest education, and proportion of females) of each occupational cluster is given in the full report.

Some of the other key findings of the study were:

- The engineering technical workforce has an average age of 33 years, and an average salary of $23,000 (at April, 1985).
- The majority of engineering technical workers are employed by government or semi-government organisations.
- The <u>overall</u> ratio of engineering technical workers to professional engineers was found to be about 1.9 to 1. The ratio of engineering technical workers to engineering tradesmen was found to be about 1 to 1.6. These ratios vary widely between the government and private sector and vary with other factors, such as size of organisation.

- Government organisations have a higher ratio of technical workers to professional engineers than private organisations and larger organisations have a higher ratio of technical workers to professional engineers than smaller organisations.

- The percentage of females in the engineering technical workforce was, not surprisingly, found to be quite low, at 2.6%. The percentage varied greatly among the different occupational clusters.

- The 621 tasks in the inventory used in the second survey were divided into 61 duties. Of these 61 duties, the five making the highest contribution to the job of the "average" engineering technical worker were:

  - written communication;
  - oral communication;
  - general administration;
  - the use of calculators and computers;
  - engineering drawing.

- Many of the duties performed bv the members of each primary cluster are common to other clusters. The balance of common duties and specialised duties varies among clusters, but over the 99 primary clusters and four major clusters, five of the 61 duties were found to be very broadly performed, being common across the four major clusters, and four were found to very specialised, being performed to any significant degree by the members of just one cluster. Of the 61 duties in the inventory, the following 15 duties were found to be commonly performed in two or more of the four major clusters:

  - written communication;
  - oral communication;
  - general administration;
  - use of calculators and computers;
  - staff supervision;
  - engineering drawing and graphics;
  - design drafting;
  - data collection and analysis;
  - maintenance;
  - finance and estimating;
  - engineering survey drafting;
  - quality testing and measuring;
  - project planning and management;

NOTES: 1. The number at the top of each box or circle is the 'cluster number' which has been assigned during the clustering process. The numbers in parentheses refer to the number of respondents in each cluster.

2. Only the larger clusters are shown in this summary.

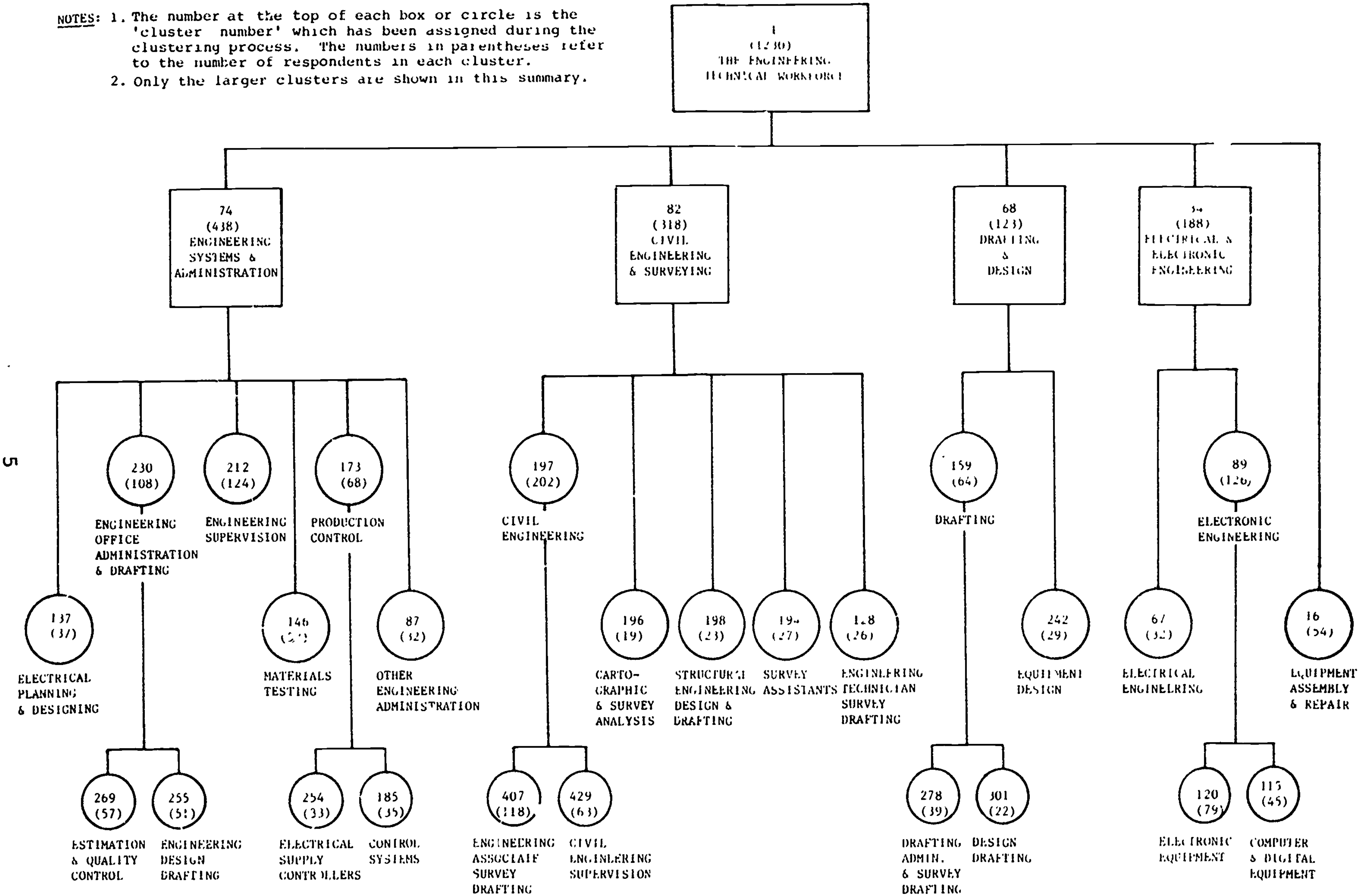


Figure 1.1 Summary of the cluster diagram

. site inspection and investigation;
. staff development.

- Two levels may be identified in the engineering technical workforce. People within the one level, termed engineering associate level, generally require more formal education and the undertaking of a wider range of tasks than those in the second level. People in the second level, termed engineering technician level, generally require more highly specialised knowledge and skills, and much on-the-job training. Despite this finding, many of the primary clusters were found to consist of members having educational qualifications across the two levels, and who performed job functions across the two levels.

- As many as 29 of the 99 primary clusters identified in the study were composed of members requiring a mixture of skills across traditional engineering branches, the most common combination being a mixture of mechanical with electrical or electronic tasks.

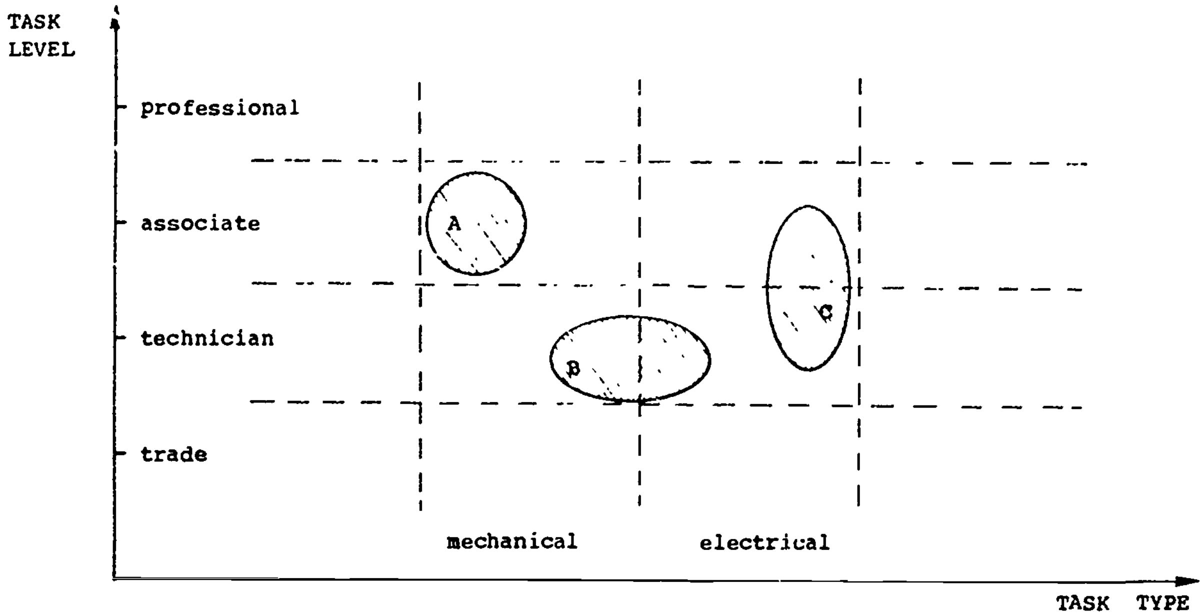
These last two findings have important implications for the way education and training programs are designed.

Essentially the study found that the traditional engineering branch boundaries defined many of the occupational clusters, and that the boundary between the levels within the engineering technical workforce also defined many of these clusters. Cluster A in Figure 1.2 illustrates this type of luster, which may be termed a single discipline, single level cluster. This basic structure enables specialised courses to be designed to suit the needs of occupational clusters within each branch and level, and the present TAFE course provision largely follows this pattern, although technician level courses are lacking in some areas.

Superimposed on this basic structure is the phenomenon of blurring, in which a significant number of occupational clusters cut across the traditional engineering branch boundaries and across the two levels within the engineering technical workforce. Such blurring is also known to occur in occupations outside engineering. Clusters B and C in Figure 1.2 illustrate these two types of blurred cluster.

The present TAFE course provision in Australia has, to a large extent, not been flexible enough to closely match the needs of multi-level and multi-discipline occupational clusters, and

Recommendations 6 and 7 address this problem. Matching the needs of these occupational clusters does not necessarily mean the provision of 'blurred' courses. What is recommended is the provision of sharply focused courses that meet the various needs of different occupational clusters through flexibility.



NOTE: Cluster A = single discipline, single level cluster
Cluster B = multi-discipline cluster (blurring across mechanical- electrical boundary)
Cluster C = multi-level cluster (blurring across technician-associate boundary)

Figure 1.2 Three types of occupational cluster illustrated in a two dimensional task domain

1.2 MAIN CONCLUSIONS AND RECOMMENDATIONS

Heterogeneous clusters

The clustering process sorted most of the 1230 respondents into 109 primary clusters. Ten of these clusters were too heterogeneous to be considered as representing a single job type, leaving 99 primary clusters that were easily interpretable. Each of these 99 clusters represents a single job type or occupation in the engineering technical workforce occupations.

The ten heterogeneous clusters represent a population having a diverse range of job types, most being in the area of mechanical, electrical and electronic equipment. All ten clusters were adjacent to the major cluster of Electrical and

Electronic Engineering. Further study of these is required to obtain job profiles and information on their education and training needs. It is suspected that formal education does not presently provide well for their education and training needs because of the diversity in their job profiles.

Recommendation 1 (page 126)

That a study be undertaken of the section of the engineering technical workforce represented by the ten heterogeneous outlying clusters found in this study. The purpose of the study should be to determine the job functions and education and training needs of this section of the workforce.

Educational programs for all occupational groups

The primary clusters found in this study represent the spectrum of occupational groups in the engineering technical workforce. This report provides a job profile (at the duty and task level) and profile on background variables of each primary cluster. It is suggested that TAFE and other providers of education and training for the engineering technical workforce compare the needs, represented by these clusters, with their current overall provision of engineering courses. It is likely that suitable education programs are not available for all of these occupational groups in all States and Territories.

Recommendation 2 (page 127)

That TAFE Authorities and other education and training providers use the results of this study to review their current courses for the engineering technical workforce. In particular, the needs of the engineering technical workforce, represented by the occupational clusters found in this study, should be compared with each Authority's overall provision of engineering courses.

Occupational groups requiring close attention

Ten primary clusters were found to have a high proportion of members having unusual educational qualifications, and this may indicate a gap in the provision of suitable TAFE or CAE courses for the particular needs of the occupational group represented by each cluster. In this study unusual educational qualifications were defined as either:

. completion of <u>other</u> courses (i.e. not mainstream TAFE, CAE or University courses) as the highest educational qualification;

. commenced but <u>not continued</u> certificate or associate diploma courses as highest educational qualification;

. blank response to the survey question on educational qualifications (which may indicate <u>no</u> post-school educational qualifications).

The ten primary clusters having a high proportion of unusual educational qualifications are:

- Cluster 609 Electronic Engineering Supervisors
- Cluster 357 Trade Supervisors
- Cluster 632 Materials Test Technicians/Officers
- Cluster 576 Electro-mechanical Engineering Officers
- Cluster 261 Engineering Survey Assistants
- Cluster 338 Engineering Survey Drafters
- Cluster 562 Senior Microelectronic Maintenance Technicians
- Cluster 315 Computer and Digital Equipment Installation Technicians
- Cluster 092 Electronic Supervisors

Recommendation 3 (page 129)

In reviewing their engineering courses, TAFE Authorities and other education and training providers should closely examine those occupational clusters in this study signalled as having a higher proportion of unusual educational qualifications.

<u>Common duties</u>

The study found that many of the 61 duties used in the survey were common across a large number of the occupational clusters. Five duties were common to all four major clusters, these duties being:

C. written communication
D. oral communication
B. general administration
R. use of calculators and computers
H. staff supervision.

In addition, three duties were common to three major clusters, seven duties were common to two major clusters, 18 duties were common to clusters in one major cluster, 24 duties were common to two or more primary clusters only, and four duties were specialised, each being performed in just one primary cluster.

The study was only able to determine the degree of commonality at 'face value'. Duties that are described similarly for two people may in fact be quite different when each person's work is very closely observed and analysed.

The results indicate that common or core curriculum units or modules could, subject to the above qualification, be developed for a range of occupational groups. Areas where low student numbers are likely should be a priority, as common or core curriculum units provide a basis for obtaining larger classes.

Recommendation 4 (page 132)

That common or core curriculum modules be developed in those areas judged, on the basis of the results of this study and other information, to be sufficiently common to two or more engineering occupational groups.

Two levels

The study found evidence for the existence of two levels in the engineering technical workforce.

People within one level, termed engineering associate level, generally required more formal education and the undertaking of a wider range of tasks than those in the second level. People in the second level, termed engineering technician level, generally required more highly specialised knowledge and skills, and much on-the-job training.

Some writers suggest that TAFE in general provides well for the needs of associate level occupations but few courses are provided for technician level occupations. This study provided evidence that many technician level workers had partly completed certificate or associate diploma courses.

This situation is of concern to some writers, who suggest that partly completed certificate or associate diploma courses may not provide an appropriate education for engineering technician occupations, as these courses are primarily designed around

the needs of engineering associate occupations. This issue is likely to increase in significance in the future, as many have predicted an increase in the numbers employed in engineering technician occupations.

Recommendation 5 (page 135)

That TAFE Authorities and other education and training providers recognise the existence of two engineering occupational levels between trade and professional level, and that these be termed:

- *engineering technician level;*
- *engineering associate level.*

Further, that education and training programs be provided for occupational groups within each level, appropriate to their particular needs.

Blurring across levels

While there was evidence for the existence of two levels in the engineering technical workforce, many of the primary clusters were found to consist of members having educational qualifications across the two levels, and who had performed job functions across the two levels. For example, when the primary clusters were analysed with respect to:

- highest educational qualification;
- task level;
- number of tasks,

as many as 20 of the 99 primary clusters were classed as 'blurred' across the technician-associate boundary. Of the remainder, 67 were classed as primarily associate level and 12 were classed as primarily technician level.

The blurring across the technician-associate boundary indicates that members of these occupational clusters may require some combination of associate level and technical level education, where separate educational programs are offered for each level, or at least transfer between levels should be allowed for and facilitated.

Recommendation 6 (page 137)

In cases where separate educational programs are designed for each of the two engineering technical workforce levels, that:

- *transfer between programs in both directions be facilitated with appropriate amounts of credit allowed;*
- *where modular course design is employed, some modules (optional or compulsory) be made common to both programs to allow for overlapping of levels.*

<u>Blurring across disciplines</u>

The work of the engineering technical workforce, as represented by the task inventory developed for this study, was divided into four broad job function areas. Tasks and duties that were judged to be not specific to a particular engineering discipline were classed in the <u>general</u> area. The other three areas were judged as specialised, these being:

- mechanical/manufacturing,
- electrical/electronic,
- civil engineering/surveying.

Most of the primary clusters performed work in the general area and one specialised area. However, 29 of the 99 primary clusters performed work, to a significant degree, in two or three of the specialised areas. These clusters were termed <u>multi-discipline</u> clusters.

The existence of these clusters and the likely trend towards an increase in 'blurring' across discipline boundaries, have important implications for the design of engineering technician and associate level courses. At present courses are generally structured within one major area. Students requiring skills in a combination of areas may be required to complete a course in one area only and take additional subjects in another area.

A practical approach to this need is to provide educational programs in a modular system, giving sufficient flexibility to allow appropriate programs for both mono-discipline and multi-discipline occupations.

Recommendation 7 (page 140)

That educational programs designed for the engineering technical workforce be designed in a modular system to allow appropriate choice of modules for:

- *mono-discipline, or*
- *multi-discipline*

occupations. Such programs should comprise appropriate combinations of:

- *common or core curriculum modules;*
- *specialised curriculum modules designed for single-discipline clusters;*
- *specialised curriculum modules designed for multi-discipline clusters.*

Future trends

A number of writers have referred to one or both of the following trends in engineering occupations:

- an increase in the degree of 'blurring', with more occupations requiring skills across two or more engineering disciplines;
- an increase in the numbers required in technician level occupations.

If these trends continue, the results of this study and similar studies will steadily become out-of-date and therefore less useful to TAFE and other education and training providers.

To address this problem, it is suggested that a study or studies be undertaken of present and near future trends in engineering technical workforce occupations.

In addition, a future major study could be conducted of all engineering technical workforce occupations around 1990. The study should employ a methodology similar to the present study, and use the task inventory from the present study. Such a study would provide valuable comparisons with the results of the present study and thus indicate possible longer term trends.

Recommendation 8 (page 143)

That a study or studies be undertaken of present and near future trends in engineering technical workforce occupations, using the results of the present study as a starting point.

That, in addition, a future major study be undertaken of engineering technical workforce occupations around the year 1990, the study using the task inventory from the present study.

CHAPTER TWO: INTRODUCTION

2.1 DEFINITIONS

The following definitions have been used throughout this report.

Engineering Technical Workforce

The engineering technical workforce is the group that includes all staff primarily performing engineering functions between tradesperson and professional engineer or surveyor. It includes engineering associates and engineering technicians, as defined below.

Engineering Technical Worker

An engineering technical worker is any member of the engineering technical workforce.

Professional Engineer

The definition provided by Lloyd has been used in this report. His definition of the professional engineer follows:

> A professional engineer engages upon work that is predominantly intellectual and varied and involves the possession of highly developed personal abilities and skills, used in the analysis of engineering problems and in their creative and economic solution.
>
> The professional engineer is competent to undertake such work by virtue of professional engineering education designed to give a thorough insight into the advanced engineering science and practice of his branch of engineering and a broad general appreciation of the principles and concepts of other branches.
>
> The professional engineer is able to follow progress in his branch by consulting newly published work, assimilating such information and applying it independently. He is thus capable of exercising original thought and professional judgement and of assuming professional responsibility for the

development and application of engineering science and knowledge in one or more phases of engineering practice, for example in research, design, construction, manufacture, operation or maintenance, or in the management of such activities, or in the education of professional engineers or engineering associates.

Initially, the qualified engineer gains experience and training under the supervision of experienced engineers. With some experience he is capable of undertaking responsible, semi-independent professional practice, requiring consistent exercise of discretion and judgement in its performance.

With further experience, the professional engineer may assume responsibilities either as a team leader or as a professional specialist, with work assigned and reviewed within broad guidelines. At senior level, he may attain operational management responsibilities, or undertake independent practice or become the proprietor of a business.

At executive levels, the professional engineer assumes responsibilities as an executive manager or as a specialist consultant in a large organisation, or as a principal in a consulting practice or in a business enterprise.

The conduct of the foregoing professional engineering functions requires the possession of a professional engineering qualification accredited by the Institution of Engineers, Australia, for admission to corporate membership. (Lloyd et al., 1979, p. 16)

<u>Engineering Associate</u>

The definition provided by Lloyd has been used in this report. His definition of the engineering associate follows:

An engineering associate engages upon work that is predominantly mental and involves the possession of highly developed personal abilities and appropriate manual skills, used in the analysis of technical problems and in their solution in accordance with established practices and precendents.

The engineering associate is competent to undertake such work by virtue of technical education and training designed to give a thorough practical appreciation of the practices and precedents of a substantial body of knowledge associated with a branch of engineering.

The engineering associate is able to apply in a responsible manner proven techniques commonly understood by those expert in the branch of engineering concerned, or techniques prescribed by professional engineers in that branch. He is thus capable of assuming technical responsibilities associated with the development and design, erection and commissioning, or operation and maintenance of engineering equipment or structures, or of associated managerial functions, or the education of engineering associates, engineering technicians or tradesmen.

Initially, the engineering associate gains experience and training under close supervision. He is capable of providing support functions for professional engineers or, with adequate experience, of undertaking responsible, semi-independent technical functions.

With further experience, the engineering associate may assume responsibilities as a team leader, or as a specialist on more important or complex work, under the general supervision of a professional engineer or a senior engineering associate, or he may become the proprietor of a small business or provide independent contract services.

At executive levels, the engineering associate assumes responsibilities for groups of engineering associate functions in a large organisation, or he may be the manager or proprietor of a business enterprise.

The conduct of the foregoing engineering associate functions requires the possession of a technical qualification accredited by the Australian Institute of Engineering Associates for admission to graduate membership, or equivalent educational attainments.

(Lloyd et al., 1979, p. 17)

Engineering Technician

The definition provided by Lloyd has been used in this report. His definition of the engineering technician follows:

> Engineering technicians may work in office-related or in trade-related workforce situations.
>
> An engineering technician in an engineering office engages upon work that is essentially mental and may be accompanied by manual skills in drafting, applied to the performance of less complex technical functions according to established practices. The performance of such functions depends upon a technical education and training sufficient to enable the engineering technician to apply, with guidance, less complex techniques and practical knowledge to limited specialised technical tasks.
>
> An engineering technician in a trade-related occupation essentially is engaged upon highly skilled manual work and exercises associated mental skills in the operation and manipulation of complex machines or processes. The performance of such functions depends upon a technical education usually associated with trade apprenticeship, but beyond trade level, enabling the engineering technician to apply difficult standard operational and diagnostic techniques to complex equipment or systems, or to undertake routine laboratory testing functions.
>
> Initially, the engineering technician gains experience and training under close supervision. With some experience, in office-related occupations, he performs support functions for professional engineers or engineering associates. In workshop or laboratory situations he carries out highly skilled tasks under general supervision.
>
> In either case, the engineering technician may become a team leader or the proprietor of a small business. With further experience, he may assume managerial responsibilities for groups of technician or trade functions, or he may become the manager or proprietor of a business enterprise.
>
> The conduct of the foregoing engineering technician functions requires the possession of a technical

qualification that requires a level of attainment less than that for an engineering associate but more than that of an engineering trade education.

(Lloyd et al., 1979, p. 18)

Engineering tradesperson

The definition provided by Lloyd has been used in this report. His definition of the engineering tradesman follows:

> An engineering tradesman engages upon work that is essentially manual and physical, and exercises associated mental skills in the performance of the tasks of a recognized trade. The performance of such functions depends upon the completion of a trade apprenticeship and an associated technical education in the theory and practice of the trade.
>
> The engineering tradesman is capable of undertaking the standard functions of the trade, and of adapting trade theory and practice, with instruction, to the new machines, systems or processes of the trade. Initially, the tradesman carries out trade tasks under supervision. With experience, he may assume responsibilities as a foreman or senior foreman, or he may operate his own small business.
>
> Some tradesmen may progress to the management of trade groups in a large organisation or as the proprietor of a business enterprise. (Lloyd et al., 1979, p. 19)

2.2 RATIONALE

Much of the recent literature on the engineering workforce has examined the existence of different occupational levels in the engineering field. There is general agreement in Australia and in other developed countries that there are four distinct levels, from engineering tradesperson to professional engineer (Henneken et al., 1983; French, 1981). The two middle level engineering occupational levels are of particular interest to TAFE. There are also of interest to colleges of Advanced Education (CAEs) in those States where middle level educational programs are offered by CAEs. There is a need to explore the nature of these two levels using empirical techniques. The following questions may be addressed by such analyses:

- Are the two levels quite distinct, or do they overlap considerably in the job functions they perform?

- What is the extent of TAFE training in each level in each State or Territory?

The present overall pattern of provision of engineering middle level courses is based on the traditional division of engineering into fields such as civil, mechanical and electrical, and more specialised fields such as marine engineering and automotive engineering. An empirical analysis of the engineering middle level occupations would provide a sound basis for determining the optimum overall pattern of provision of these courses. An Australia-wide empirical analysis of the engineering occupations has not been conducted in recent years. Such an analysis would be able to determine the current impact of new technology in the engineering technical workforce. It would also indicate job tasks that appear to be common across engineering fields.

Within each field of engineering and within each State or Territory of Australia, courses are developed based on the needs of industry. These needs are identified by different methods in each State. Typically the curriculum is centrally developed for a population of students whose individual needs and characteristics have been averaged out. Such a system, while providing for the needs of the 'average student', may not match the vocational needs of individual students, or small groups of students. Within an occupational population of workers there may be quite distinct sub-populations. While there may be many job tasks that are common to two or more sub-populations, many job tasks will be unique to one sub-population of workers.

A better understanding of the nature of the engineering technical workforce's skill needs will provide an avenue to the development of flexible courses with curricula tailored to meet specific student needs.

2.3 OBJECTIVES

The objectives of this study were:

- To empirically determine the existence or otherwise of vertical clusters showing the two hypothesised distinct levels of engineering technical workers in Australia.

- over all fields of engineering
- within each field of engineering.

- To empirically determine the existence or otherwise of task/skill horizontal clusters showing distinct fields of engineering occupations such as civil, mechanical, electrical, electronic.

- To determine the existence or otherwise of occupational clusters within each main cluster group.

- To determine the existing characteristics of each cluster identified, including job skill profile, job title, job experience, educational attainment, field of engineering, size of employer organisation, public/private sector, salary, and State or Territory. The job task/skill profile is to include quality control and computer tasks.

- To compare the task profiles of the identified clusters, and thus provide basic data for curriculum developers. Specifically to determine those tasks which are common to two or more clusters and those tasks which are specialised to one cluster.

CHAPTER THREE: LITERATURE REVIEW

3.1 OVERVIEW OF STUDIES ON THE ENGINEERING TECHNICAL WORKFORCE

There is not a large amount of literature on the engineering technical workforce. This contrasts with the large amount of literature on engineering tradesmen and professional engineers.

This point is illustrated by a recent search of the ERIC database by the author which revealed:

- 1900 documents concerned with 'engineers';
- 138 documents concerned with 'engineering technicians' (i.e. engineering)
- 255 documents concerned with 'trade and engineering' (there is no ERIC descriptor for 'engineering tradesmen' or equivalent).

The United States National Technical Information Service (NTIS) has:

- 7042 reports concerned with 'engineers';
- 637 reports concerned with 'technicians and engineering';
- 3747 reports concerned with 'trade and engineering'.

This is further illustrated by the fact that the Australian Bureau of Labour Market Research has produced:

- 6 papers on engineers;
- no papers on engineering technical workers;
- 3 papers on tradesmen and apprentices (including those outside engineering).

A possible reason for the relative dearth of literature on the engineering technical workforce is its more recent emergence as a distinct and well defined occupational group. In contrast,,

tradesmen and professional engineers are occupational groups that have definitions that have long been accepted and generally understood (EITB, 1983a, p. 2).

3.2 ENGINEERING OCCUPATIONAL LEVELS AND TERMINOLOGY

It is apparent from the literature that there is much interest in, and much debate over, the grades or levels of occupations and the terms used to describe them.

There is considerable agreement on the existence of four engineering occupational levels requiring formal post-school education. The first of these levels, requiring the least amount of formal education, is the level usually termed engineering trade level. Engineering tradespeople use manual skills requiring knowledge of engineering practices and knowledge of specific machines and techniques. They require a relatively small amount of knowledge of general engineering and scientific principles. At the other end of the scale is the group of professional engineers. Professional engineers require a relatively small amount of manual skill and a relatively large amount of knowledge of general engineering and scientific principles. In between these two levels is the broad group of engineering technical workers, which is usually split into two groups - an upper level and a lower level. The required levels of manual and conceptual skill are recognised as being intermediate between tradespeople and professional engineers.

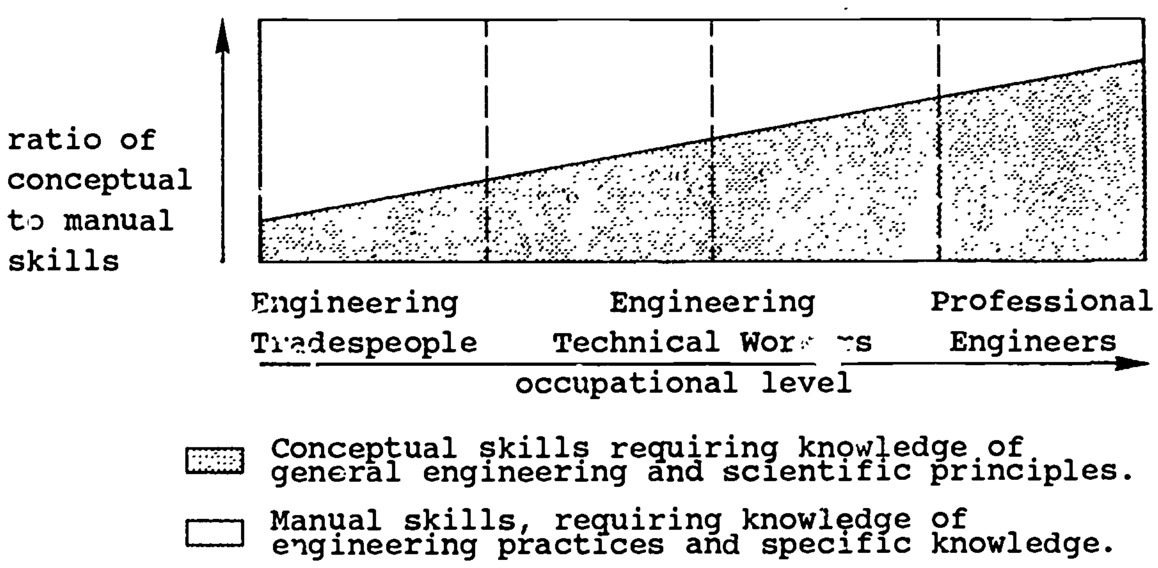


Figure 3.1 Diagrammatic representation of the spectrum of engineering occupations

Figure 3.1 provides a useful diagrammatic representation of the spectrum of engineering occupations, from tradesperson to professional engineer. A single occupation would be represented by a vertical line in the diagram. It provides a simple model of engineering occupations and their skill requirements. Most of the literature concerned with engineering occupational levels uses or assumes this basic model, as represented in Figure 3.1.

Before turning to the literature on engineering occupational levels, it is worth noting one important aspect of the model. The group of engineering technical workers is represented as a very broad group. Those at the far right require much coneptual skill, not unlike professional engineers. Those at the far left require much manual skill, not unlike tradespeople. This point is emphasised by some writers, who see engineering technical workers as a heterogeneous group comprised of an upper and lower level and requiring quite separate formal educational qualifications. As we shall see, this is one of the key issues in the literature.

French (1981) undertook a UNESCO study of engineering occupational nomenclature and classification in 39 nations. He found that a large majority of countries recognised two levels between engineering tradespeople and professional engineers.

Thirty of the thirty-nine countries surveyed recognised two levels in the engineering technical workforce. The remaining nine countries recognised one or three levels but some of these were considering recognising two levels.

Although he acknowledged that Australia, France and U.S.A. were against the use of the term 'engineer' for grades below the professional level, he advocated the general adoption of the following terms, or their equivalents in other languages, for the four levels above operator:

- professional engineer;
- technician engineer;
- technician;
- tradesman.

These terms are used in Britain. He also suggested the term 'higher technician', as used in France, as an alternative to 'technician engineer'.

In the United States four engineering occupational levels are widely recognised, these being termed:

- engineers;
- engineering technologists;
- engineering technicians;
- skilled workers.

However, the educational qualification required by engineering technologists is higher than that required for engineering associates in other countries (French, 1981, p. 138-9), and this has led to some problems of differentiating engineers from engineering technologists. In some States, engineering technologists have been able to register as professional engineers (Ball and Snarponis, 1978).

The most pertinent overseas research studies on the engineering technical workforce are two major studies conducted by the Engineering Industry Training Board in the United Kingdom. The earlier study (EITB, 1970) found, among other things, that there were two levels within the engineering technical workforce, and these were termed:

- technician engineers,
- other technicians.

Despite the evidence for the existence of the two levels, a clear distinction in duties between these two levels was not found. While there was not much difference in the kind of activities undertaken by workers in each of the two levels, it was found that the higher level required a greater breadth of knowledge and a wider range of activities.

The later study (Connor, 1983) divided the engineering technical workforce into three groups:

- engineering technicians;
- draftsmen;
- other technical staff.

The group called 'other technical staff' mainly comprises those employed in non-engineering occupations. The 'engineering technicians' and draftsmen were each divided into a higher and a lower level. The terms used for each category are shown in Table 3.1.

The 1983 study also found evidence supporting the existence of two levels. After being shown definitions of each of the two levels, most employers agreed that two distinct levels existed, 91% saying that two levels existed within 'engineering technicians' (i.e. engineering technical workers excluding draftsmen) and virtually all employers agreed that two levels existed within draftsmen. It was estimated from the employers' replies that about half of the 'engineering technicians' were working at the upper level and about three-fifths of the draftsmen were working at the upper level. Table 3.1 shows the estimates given in the EITB study for the number of workers in each of the main categories.

TABLE 3.1 TERMS USED BY THE EITB (U.K.) FOR EACH OCCUPATIONAL CATEGORY IN THE TECHNICAL WORKFORCE, AND ESTIMATED NUMBERS IN EACH CATEGORY (FROM CONNOR, THE TECHNICIAN IN ENGINEERING, PART 1, 1983)

	TECHNICAL WORKFORCE GROUP		
LEVEL	engineering technicians (144,000)	draftsmen (54,000)	other technical staff (18,000)
Higher level	technician engineers (75,000)	technician engineer draftsmen* (32,000)	not given
Lower level	other engineering technicians (69,000)	lower level draftsmen (22,000)	not given

* In the EITB report (Connor, 1983) the term 'higher level draftsmen' is also used

In Australia the issue of two levels within the engineering technical workforce and the related issue of terminology have occupied a significant part of the literature on the engineering technical workforce.

However, it appears that only a little research has been conducted on the existence of the two occupational levels in Australia.

In 1976 and 1977 the Technical Education Division of the Education Department of Western Australia conducted a survey of 87 employers comprising 50 private firms and 37 government organisations. The researchers defined four categories of engineering workers as follows:

- Category I - professional engineers, defined by qualifications;
- Category II - engineering technical workers - higher level, defined by qualification;
- Category III - engineering technical workers - lower level, defined by qualification;
- Category IV - employees receiving education and training for one of the above positions.

(Cochrane, 1977, p. 2)

All except one private firm and one government department were able to provide data on the number of employees in each category. These data are summarised in Table 3.2.

TABLE 3.2 NUMBER OF EMPLOYEES IN EACH OCCUPATIONAL CATEGORY (SOURCE: Cochrane (1977) Survey of industry needs for engineering courses at the TAFE level

TYPE OF ORGANISATION	NUMBER OF EMPLOYEES CAT. I	CAT. II	CAT. III	CAT. IV
Private	502	344	130	103
Government	587	1289	258	487
TOTAL:	1089	1633	388	590

These data indicate a much smaller number of lower level technical workers (CAT.III) than higher level technical workers (CAT.II). There also appears to be a relatively high number of workers receiving education and training. The authors predict a significant increase in the number of categories II and III workers because of this result.

Employers were also asked if category I (professional engineers) were engaged wholly or in part in work which could be satisfactorily handled by category II or III staff. Of the 50 private organisations, 56% replied 'yes'. Of the 37 government organisations, 41% replied 'yes'. They were also asked if category II and III engineering staff were engaged in category I work, resulting in 44% of private organisations replying 'yes' and 24% of government organisations replying 'yes' (Cochrane, 1977, p. 22).

The authors interpreted this result as a considerable overlap in the functions of professional engineers and engineering associates in a significant number of organisations, with private firms indicating

> a significantly more flexible attitude to this issue essentially based on the pragmatic approach of letting personnel do the work on the basis of their abilities and experience. (Cochrane, 1977, p. 22).

Over the past few years Brian Lloyd has authored or co-authored a number of books or articles on these issues. <u>Engineering Manpower in Australia</u> by Lloyd et al. (1979) draws together many of the important ideas in his earlier works. Lloyd observes that occupations in science and engineering are more structured than in other areas such as commerce and accounting, there being six identifiable occupational levels in science and engineering as follows:

- professional level;
- middle level;
- technician level;
- trade level;
- operative level;
- general labour level.

The first four of these require formal post-school education.

Lloyd asserts that two occupational levels between professional level and trade level have evolved in Australia in science and

engineering. For engineering occupations he proposes the general use of the terms 'engineering associate' for the higher level occupations (i.e. at middle level) and 'engineering technician' for the lower level occupations (i.e. at technician level). The general term to cover engineering occupations at either of these two levels is 'engineering technical workforce'.

Table 3.3 summarises the terms recommend by Lloyd, et al. (1979) in <u>Engineering Manpower in Australia</u>.

The use of these engineering terms has subsequently been fully or partly supported by various groups in Australia and these terms have been adopted in this present study.

Lloyd (1984) also calls for precision in the use of the terms 'engineer' and 'technician'. He states that the term 'engineer' should be used only for the professional level, and therefore does not support the use of the U.K. term 'technician engineer' for the engineering associate category. The varying uses of the term 'technician' are confusing. Sometimes it is used to describe all occupations between the trade and professional level and sometimes it is used to describe occupations at the lower level of the engineering technical workforce. Lloyd argues that such confusion should be removed by using the term only for the lower level of the technical workforce.

TABLE 3.3 BROAD TERMS AND CORRESPONDING ENGINEERING TERMS AT EACH OCCUPATIONAL LEVEL (FROM LLOYD ET AL., 1979)

BROAD TERM FOR SCIENCE AND ENGINEERING	TERM FOR ENGINEERING
Professional level	professional engineer
Middle level	engineering associate
Technician level	engineering technician
Trade level	engineering tradesman
Operative level	-
General labour level	-

In <u>Engineering Manpower in Australia</u> (Lloyd, et al., 1979, p. 10-20), Lloyd provides a general definition of each of the four engineering occupational levels from trade to professional level in terms of the

- level of activities (particularly the amount of manual and mental work);

- scope of activities (including degree of original thought and amount of guidance required);

- education and training required.

He states that the specification of the educational level required is an essential element of the definition. The definitions indicate the necessary relationship between the level and scope of the activities of the occupational category and the education and training required for those employed in the occupational category.

Importantly, Lloyd distinguishes two dimensions from the occupational level dimension. One dimension is that of occupational area (e.g. engineering, applied science). The other dimension is career progression or degree of supervision. Within each occupational level, three levels of career progression are identified (Lloyd, et al., 1979, pp. 10-14). These are:

- base level;
- senior level;
- executive level.

The Institution of Engineers, Australia and the Australian Institute of Engineering Associates have produced a joint publication entitled <u>Guidelines on Education for the Engineering Industry</u> (1983). This publication defines four workforce categories for the engineering industry from engineering tradespeople to professional engineers. These four categories are:

- professional engineer;
- engineering associate;
- engineering technician;
- engineering tradesman.

The definitions are largely based on those provided in Lloyd et al., (1979). The <u>Guidelines</u> booklet is significant in Australia because it provides support for the concept of two occupational levels between trade and professional and also because it gives impetus to the use of standard terms to describe each level.

The current Australian Standard Classification of Occupations (ASCO) also recognises two occupational levels between trade and professional level in science and technology occupations, including engineering (DEIR & ABS, 1983). 'Technical officer', is the generic term for the higher of the two levels in science and technology occupations, and 'technician' is the generic term for the lower of the two levels in science and technology occupations.

TABLE 3.4 THE ASCO ENGINEERING ASSOCIATE AND ENGINEERING TECHNICIAN OCCUPATIONS (SOURCE: DEIR & ABS, 1983)

CODE	TITLE
2046	ENGINEERING DRAFTING AND OTHER TECHNICAL OFFICERS
2046-A	Technical Officer, Civil Engineering
2046-B	Technical Officer, Electrical Engineering
2-46-C	Technical Officer, Electronics Engineering
2046-D	Technical Officer, Mechanical Engineering
2046-E	Technical Officer, Process Control
2046-F	Draftsman/woman, Civil Engineering
2046-G	Draftsman/woman, Structural Engineering
2046-H	Draftsman/woman, Electrical Engineering
2046-I	Draftsman/woman, Electronics Engineering
2046-J	Draftsman/woman, Mechanical Engineering
2046-Z	Engineering Drafting and other Technical Officers NEC
2047	ENGINEERING TECHNICIANS AND DRAFTING ASSISTANTS
2047-A	Engineering Technician, Civil
2047-B	Engineering Technician, Electrical
2047-C	Engineering Technician, Electronics
2047-D	Engineering Technician, Mechanical
2047-E	Drafting Assistant, Civil Engineering
2047-F	Drafting Assistant, Electrical Engineering
2047-G	Drafting Assistant, Electronics Engineering
2047-H	Drafting Assistant, Mechanical Engineering
2047-Z	Engineering Technicians and Drafting Assistants NEC

Note: NEC = Not elsewhere classified

In listing the engineering associate occupations, ASCO separates the drafting occupations (titled 'draftsman/woman' with the branch of engineering given) from the other technical officer occupations. A similar policy is applied to engineering technicians where the drafting occupations (titled 'drafting assistant' with the branch of engineering given) are separated from the other engineering technician occupations. Table 3.4 lists the 11 engineering associate and 9 engineering technician occupations specified in ASCO.

Thus ASCO implicitly recognises the existence of two occupational levels between trade and professional in each of the main branches of engineering. It is also significant that these two levels are recognised outside engineering occupations.

A major study for the Queensland Industry & Commerce Training Commission examined the structure and training requirements of the engineering technical workforce in Queensland (Henneken, et al., 1983).

The study, entitled <u>Engineering Middle Level Workforce Study</u>, reviewed some of the most pertinent Australian literature on the engineering technical workforce and surveyed employers in Queensland. Based on the survey results, the authors concluded that two occupational levels existed in the engineering technical workforce. The report recommended the adoption of the terms:

- professional associate;
- technician (or post-trade),

for the upper and lower levels respectively. These terms correspond closely with the terms proposed by Lloyd, et al. (1979), namely:

- engineering associate;
- engineering technician,

but are deliberately broader to enable their application in fields outside engineering.

The Engineering Middle Level Workforce Study found there was widespread confusion over the use of the term 'technician'. It recommended the replacement of the term 'technician' with 'professional associate' in the Industry & Commerce Training Act where the reference is to the higher level. It recommends the

term 'technician' be restricted to the lower level, and found the lower level to be the current and future growth area in Queensland, as in the rest of Australia.

After the distribution of the Engineering Middle Level Workforce Study report, organisations were invited to comment on it. A policy statement, based on the report and the comments on it, was prepared by the Queensland Industry and Commerce Training Commission in 1984. The Queensland Minister has approved the implementation of the policy. The policy statement was circulated by the Director of the Division of Employment Planning and Training, Department of Employment and Industrial Affairs, Mr B.C.L. Read, in 1985. Interestingly, terms more specific to engineering are used in the policy statement, these being:

- professional engineer;
- engineering associate;
- trade technician;
- tradesman.

(Read, 1985)

TABLE 3.5 SUMMARY OF THE TERMS USED IN THE MAJOR STUDIES REVIEWED TO DESCRIBE EACH ENGINEERING OCCUPATIONAL LEVEL

COMPARATIVE STUDY	U.S.A.	U.K.	AUSTRALIA			QUEENSLAND
French (1981)	Ball & Snarponis (1978) and French (1981)	Connor (1983)	Lloyd, et al. (1979)	IEA & AIEA (1983)	DEIR & ABS (1983)	Henneken, et al. (1983) and Read (1985)
Professional Engineers	Engineers	Professional Engineers	Professional Engineers	Engineers	Engineers	Professional Engineers
Technician Engineers	Engineering Technologists	Technician Engineers	Engineering Associates	Engineering Associates	Technical Officers	Engineering Associates
Technicians	Engineering Technicians	Engineering Technicians	Engineering Technicians	Engineering Technicians	Technicians	Trade Technicians
Tradesmen	Skilled Workers	Engineering Tradesmen	Engineering Tradesmen	Engineering Tradesmen	Tradesmen	Tradesmen

To conclude this section a summary of the various terms recommended and used in some of the major recent studies in Australia and overseas is given in Table 3.5. It is apparent from this Table that there is reasonable consensus on the use of the terms 'technician' for the lower level within the engineering technical workforce, but sharp disagreement exists on a term for the higher level. The ASCO term 'technical officer' reflects current job titles used widely in the public

service, but 'engineering associate' is supported by the major engineering associations in Australia. The U.K. term 'technician engineer' is strongly opposed in Australia.

There is broad agreement in the literature on the existence of two occupational levels between trade and professional level in engineering. As we shall see in the next section, the recognition of these two occupational levels does not <u>necessarily</u> carry recognition of the need for two separate educational programs.

3.3 EDUCATIONAL QUALIFICATIONS OF THE ENGINEERING TECHNICAL WORKFORCE

With respect to educational qualifications of the engineering technical workforce, two key issues arise in the literature. The first issue concerns the definition of each occupational level, and whether educational qualifications or job functions performed define each level. The second issue concerns the specification of appropriate education and training programs for each occupational level, and particularly whether the engineering technician level requires education and training programs different to those provided for the trade or associate level.

Each of these two issues are discussed in this section.

<u>Definition by qualification or job function</u>

Most of the studies cited in the previous section provided definitions of each engineering occupational level, and these definitions usually have two main components:

- types of job functions performed;
- educational qualifications that are required or are appropriate.

There are two main views on how each occupational level is defined. One view is that the types of job functions performed, including the breadth of activities undertaken, defines the worker's occupational level. A definable level of education, training and experience is <u>usually</u> necessary to be able to perform such functions.

This was the approach of the Engineering Industry Training Board in its 1983 study (Connor, 1983). The study defined both the types of functions performed at each level and the formal

educational qualifications 'probably but not necessarily' required for each of the two levels in the engineering technical workforce (Connor, 1983a, pp. 23 and 29). The engineering technical workers interviewed in the study were classified as higher or lower level, based on the perception of their functional level by their employer. Using this method some engineering technical workers classed as functioning at the lower level were found to have higher educational qualifications than that specified as standard for the lower level by the EITB. This is illustrated in the distribution of educational qualifications among the two levels as given in Table 3.6.

TABLE 3.6 PERCENTAGE DISTRIBUTION OF HIGHEST EDUCATIONAL QUALIFICATIONS FOR HIGHER LEVEL AND LOWER LEVEL ENGINEERING TECHNICAL WORKERS (FROM CONNOR, 1983B, P. 14)

Specified level of qualification	Qualifications*	Draughtsmen Higher level (n=118)	Draughtsmen Lower level (n=68)	Other Engineering technical workers Higher level (n=322)	Other Engineering technical workers Lower level (n=277)
Associate (or higher)	Degree; HNC or HND; CGLI Full Technological Certificate; TEC Higher Certificate or Diploma	51	28	41	17
Technician	ONC or OND; CGLI Technician Certificate; TEC Certificate or Diploma	37	47	29	31
Trade	CGLI Craft Certificate	1	3	7	10
Not specified	Other qualifications	1	9	8	9
Not specified	No qualifications	10	13	15	33
TOTAL:		100	100	100	100

*NOTE: CGLI = City and Guilds of London Institute; HND = Higher National Diploma; OND = Ordinary National Diploma; HNC = Higher national Certificate; ONC = Ordinary National Certificate; TEC = Technical Education Council.

The main weakness of the 'definition by function' approach is the difficulty in distinguishing the higher level functions from the lower level functions. This was one of the main findings of both of the EITB's studies in 1970 and 1983, and referred to in the previous section.

There are few studies that have attempted to systematically specify the job functions of each of the two engineering technical workforce levels. All of the studies cited in the previous section as well as Kocketkov (1977) and Chandrakant

(1975a, 1975b), cited in French (1981, pp. 24-27), have attempted to do so at a broad activity level. No studies known to the author have documented, at a detailed level, the activities undertaken by engineering technical workers over the full spectrum from lower level to higher level. French (1981, pp. 26-27) argues that there is a need for such studies, stating that

> Dr Chandrakant's broad spectrum of activities of a technician, interesting though it is, falls short of immediate practical use. What is needed is a detailed specification of subactivities, enabling us to see what is required of an electronic technician, of a design draftsman, of a process planning technician, etc.

In contrast to the 'definition by function' approach, the 'definition by qualification' approach provides clear boundaries for each occupational level in engineering. In Australia and many other countries the qualifications (i.e. formal education and practical experience) required for workers at each engineering occupational level are generally well defined and widely accepted. The only possible exception is the engineering technician level. In Australia there is no specification of the educational requirement for the engineering technician level which is widely accepted and accredited among all of the States, but guidelines have been prepared by the Institution of Engineers, Australia and the Australian Institute of Engineering Associates (1983).

If a system of definition by qualification is to be acceptable to industry (including government and semi-government bodies undertaking engineering activities), the education and training should match the functional requirements of the job (French, 1981, p. 46). This relationship between jobs and educational programs may be seen as a two-way relationship in which the education, training and work experience program is designed to suit the functional requirements of the job, and the job is patterned to fit the 'product' of the available education and training.

Definition by qualification is widely used in Australia and overseas (French, 1981, p. 46) because it provides clear boundaries between each occupational level. Its main weakness is the difficulty of classifying those with a mixture of formal or informal education, training and work experiences which do not neatly fit the specified qualification.

A further problem is that a few people appear to be satisfactorily performing engineering functions at a technician or associate level with qualifications specified for one level lower. There is prima facie evidence for this in Table 3.6 from the EITB (1983) study. The 1977 study by the Education Department of Western Australia, discussed in Section 3.2, also found considerable overlap in the functions of engineers and engineering associates. The reverse also appears to occur, namely, that a few people appear to be performing engineering functions at a technician or associate level with qualifications specified for one level higher. Perhaps the people in either of these two groups have informal education and training and/or special aptitude which fits them for the job they are performing. This issue has received little attention in the literature, and is an issue that should be researched.

Bill Ford (1986) asserts that overlap or 'blurring' of job functions will be forced upon Australian industry through the introduction of new technology and economic competition. New overseas technology usually has been developed on the assumption of flexible work organisation. This new technology, when introduced in Australian industry, will not provide optimum efficiency until more flexible work practices are employed. Horizontal blurring (e.g. across the mechanical and electronic engineering boundary) and vertical blurring (e.g. across the engineer and engineering associate boundary) will become more common in Australia as new overseas technology is introduced.

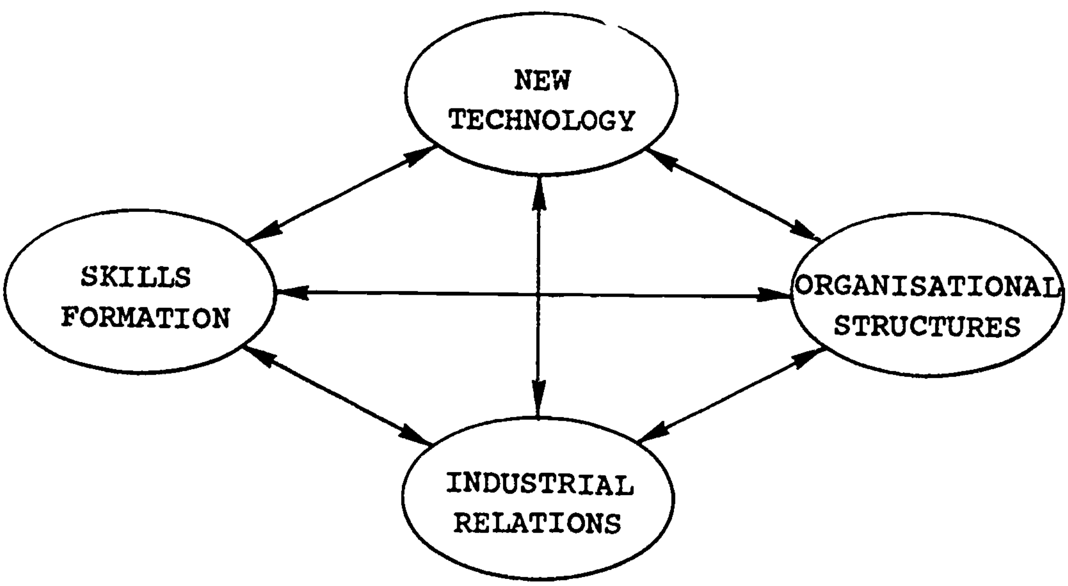


Figure 3.2 The four major work organisation influences (SOURCE: Ford, 1986)

He also asserts that there are other important influences on the way work is organised, and proposes a model which recognises four major influences on work organisation, as illustrated in Figure 3.2. The job functions of jobs are determined by:

- new technologies;
- skills formation (education and training system);
- organisational structures;
- industrial relations (e.g. demarcation by unions);

and each of these interact with each other.

Education of engineering associates and engineering technicians

French (1981), in the UNESCO study cited in the previous section, found considerable variation among the 39 nations studied in the engineering educational programs for each occupational level. However, a general pattern was perceived. Most countries which recognised two levels between professional and trade had separate educational programs for each of the two levels.

Also many countries specified a minimum period of training and related work experience before registration or recognition of engineering associates and engineering technicians.

In the United States the educational qualification for the engineering technologist (which is the term for the level between engineering technician and professional engineer) is a four-year full-time Bachelor of Engineering Technology degree from a university or four-year college. The situation is, however, not uniform across all States in the U.S.A., as some States recognise the Bachelor of Engineering Technology as a professional level engineering qualification. The educational qualification for the engineering technician is a two-year full-time course at a junior college, community college or technical institute (French, 1981, pp. 138-9; Ball and Snarponis, 1978, pp. 48-9).

The U.K. Engineering Industry Training Board defines the educational qualifications for the higher level (i.e. engineering associate) as completion of either Higher National Certificate or Diploma, City and Guilds of London Institute technological certificate, and Technician Education Council Higher Certificate or Higher Diploma. It defines the educational qualifications for the lower level (i.e.

engineering technician) as completion of either Ordinary National Certificate or Diploma, City and Guilds of London Institute Technician Certificate parts I and II, and Technician Education Council Certificate or Diploma (Connor, 1983a, p. 29).

In the 1980-81 EITB study, employers were shown definitions, which included the above-mentioned educational qualifications, of each of the two levels. They were then asked if the two levels existed in their organisation. Most employers agreed that the two levels existed, but many stated that for 'engineering technicians' their firm's practice was

> to train all their technicians using one set of training recommendations and that they expected them all to acquire the same level of further education qualifications. In some cases the trainees would go directly into technician engineer jobs on completion of training, while others would start at the lower level and progress to technician engineer jobs with age and experience (Connor, 1983a, p. 6).

Similar comments were made about the two levels of draftsmen, although draftsmen were more likely to start at the lower level on completion of training and progress to the higher level with age and experience.

The age distribution of 'engineering technicians' and draftsmen tended to confirm this. The 'engineering technicians' at the higher level had an older age profile than that of 'engineering technicians' at the lower level. A similar though more marked difference in age profile existed for the two levels within draftsmen.

Summarising the situation in Australia, French (1981, pp. 77-8) observed that engineering associate level courses are offered in all States, the predominant course being four years part-time at a technical college. The other main type of engineering associate level course is a two year full-time course at a college of advanced education, this being more common in Queensland. According to French, engineering technician level courses are not available in all States, and take two main forms:

- trade-related technician courses - four years part-time taken with indentured apprenticeship;

- office-related technician course - three years part-time.

It is important to note that some four year part-time courses taken with indentured apprenticeships are associate level rather than technician level.

In those States where formal courses designed specifically for engineering technicians are not available, it is assumed that people in engineering technician occupations usually have either:

- trade qualifications plus appropriate on-the-job training and work experience; or

- partial completion of associate level qualifications and appropriate work experience.

There are no Australian studies known to the author dealing with this issue. The present study has provided some data on this.

In <u>Guidelines on Education for the Engineering Industry</u>, the Institution of Engineers, Australia and the Australian Institute of Engineering Associates (1983) have provided guidelines on education for each of the four categories of engineering occupation, namely, professional engineers, engineering associates, engineering technicians and engineering tradesmen. It is a very useful document for engineering educators because it is clear, concise, comprehensive, and apparently the result of extensive consultation around Australia.

In addition to the fact that it defines each of the four occupational categories this document promotes the idea of educational courses designed specifically for each occupational level. On this second point it contrasts with the attitude of the majority of employers in the U.K., as reported in the EITB study, which is that one type of course is preferred for both engineering associates and engineering technicians.

There is general agreement in Australia on the types of educational qualifications required by engineering associates. The predominant qualification is a four-year part-time course at a TAFE college, but there are variations among the States and Territories. Examples are:

- Certificate of Engineering in New South Wales;
- Certificate of Technology in Victoria, and South Australia;
- TAFE Diploma in Western Australia. (Lloyd, 1985, p. 2)

The titles of these awards is expected to change to Associate Diploma within a year or two because of standardisation of titles recommended by the Australian Council on Tertiary Awards (Haydon, 1985).

The other main qualification is a two-year full-time course at a college of advanced education. This course leads to an Associate Diploma and is the predominant qualification in Queensland.

The educational qualifications required by engineering technicians are specified by IEA and AIEA (1983, p. 22) as either:

- an engineering technician course and related training and work experience, or

- further appropriate education after trade apprenticeship for the acquisition of knowledge and skills beyond trade level (as distinct from post-trade education for the enhancement of trade skills), or

- on-the-job training, either following an appropriate school preparation or a related trade apprenticeship, and involving the acquisition of knowledge and skills at technician level.

The last two qualifications point to the fact that many engineering technician occupations are closely related to trade occupations. Despite this close relationship, it is important to recognise that not all post-trade education prepares for technician occupations. Lloyd states that there are three categories of post-trade education and only the third category prepares technicians. The three categories are:

- Post-trade courses, to enhance or update trade skills, will made tradesmen better tradesmen, not technicians.

- Post-trade courses in supervision, will make better trade foremen, but trade foremen are not technicians.

- Courses that build upon the basic trade courses, to provide greater depth and breadth of knowledge and skills at a level of activity significantly above trade level, will produce technicians. (Lloyd, 1985, p. 3)

For those technician occupations that are not closely related to a trade, an engineering technician course is the preferred

qualification (IEA and AIEA, 1983; Lloyd, 1985), but Lloyd (p. 3) recognises that partial completion of an associate-level TAFE or CAE course is often the qualification held by technicians, particularly in those States that do not offer three or four year engineering technician courses. These occupations are referred to as 'office-related' by some authors, and include detail draftsmen, drafting assistants and technical assistants.

The Engineering Middle Level Workforce Study in Queensland did not appear to recognise the office-related engineering technicians. In its interim report it stated that the lower middle (i.e. technician) level undertakes work "for which a trade qualification is necessary but increasingly insufficient" (Henneken et al., 1983, p. 10). However, the policy statement from the Director of the Division of Employment Planning and Training, Department of Employment and Industrial Affairs in Queensland appears to qualify this position, stating that the technician level is <u>predominantly</u> trade-based (Read, 1985, p. 3). The term used in this statement to describe the engineering technician level is 'trade technician', and this emphasises the trade relationship.

3.4 OCCUPATIONAL ANALYSIS OF THE ENGINEERING TECHNICAL WORKFORCE

Few occupational analysis studies, involving the analysis of the component tasks of the occupation, have been undertaken for engineering technical workforce occupations.

It will be useful to classify the relevant studies using two criteria:

- whether cluster analysis has been used to determine the occupational clusters, based on similarities in tasks performed;

- whether the full spectrum of engineering technical workforce occupations, or a single branch of engineering occupations, was studied.

Studies in each of these categories were sought for review, and are discussed below.

Studies using cluster analysis

Cluster analysis provides a systematic and quantitative basis for grouping jobs that are similar in task components. Therefore occupational studies that use cluster analysis usually provide valuable insights into the smaller sub-groups within a known occupation, and/or an overview of the relationships between a group of occupations.

A search of the literature by the author revealed no studies concerned with the full spectrum of the engineering technical workforce occupations using cluster analysis.

There are, however, a series of studies conducted by Cunningham and his colleagues (see for example, Pass & Cunningham, 1977; Riccobono et al., 1974; Cunningham (Ed.), 1969), which undertook various cluster analysis of a sample of 1414 jobs, representing a wide range of jobs in the U.S.A.

These studies aimed to validate the Occupational Analysis Inventory (OAI) and clustering method for occupational studies. The OAI contains 622 'work elements', and may be used as an instrument for analysing any occupation. The clustering technique employed was a hierarchical cluster analysis within the Comprehensive Occupational Data Analysis Programs (CODAP). A similar cluster analysis method was used in the present study.

These studies have generally confirm the validity of the OAI and the cluster analysis. For example, one study found, for the main clusters derived, moderate to substantial within-cluster homogeneity, inter-cluster discriminability, and cluster stability (Pass & Cunningham, 1977).

The last study in the series (Pass & Cunningham, 1977) used 102 OAI 'first order factors', derived from the 622 work elements. These factors were used as the basis for clustering the 1414 jobs. The result of the cluster analysis was the identification of 21 broad 'macro clusters' and 88 narrower 'micro clusters'. The 88 micro clusters were reduced, by combinations, to 47 categories using judgemental criteria, and these 47 micro cluster categories are reported.

Only two of the 21 macro clusters involve engineering occupations, and within these, five micro cluster categories involve engineering occupations. These are listed in Figure 3.3.

The engineering micro cluster categories are still quite broad, and do not provide a useful detailed structure for engineering occupations.

Micro cluster category Number 21 includes professional engineering occupations over a broad range of engineering branches, plus drafting occupations. Number 22 includes electrical and electronic engineering and technical workforce occupations. Number 23 includes foremen and supervisors of production operations, and may include some non-engineering occupations. Number 43 includes occupations in electrical and

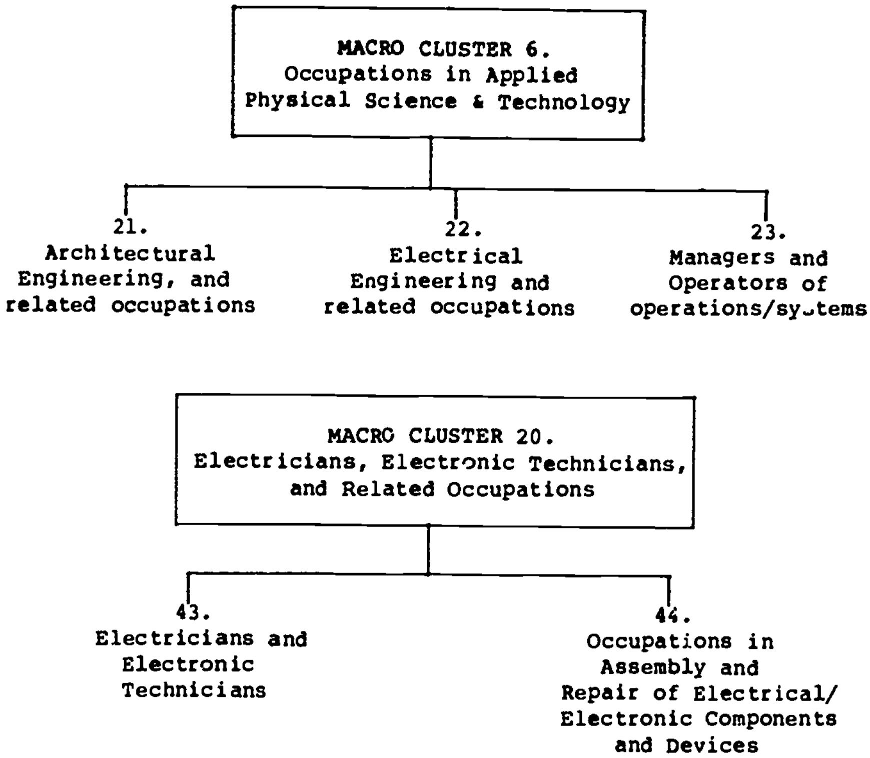


Figure 3.3 The two macro clusters and five micro clusters involving engineering occupations found in the Pass and Cunningham (1977) study

electronic inspection, repair and maintenance, these being mainly at trade level with some at technician level. Number 44 includes occupations in electrical and electronic assembly and repair, these being mainly at trade level.

<u>Other studies</u>

Studies that do not use cluster analysis to group jobs usually use one or two key variables to classify the occupational groups. Such variables include:

- branch of engineering (e.g. mechanical, electrical, electronic, and civil engineering);

- industry area (e.g. mining, agriculture, manufacturing, public administration).

The profiles of tasks performed or skill required for each group are then determined.

This method is appropriate when the broad structure of the occupation or occupations under study is well known and the smaller sub-groups are either known or are not of interest in the study.

A small number of studies of this type, covering the full spectrum of the engineering technical workforce, have been reported. The most comprehensive study reported is the study by the Engineering Industry Training Board (EITB) in the United Kingdom (Connor, 1983). Some aspects of this study have already been discussed in Sections 3.2 and 3.3. A few of the other key findings of this major study are briefly presented here.

The study involved an interview survey of 833 engineering technical workers in the 'engineering industry' in the United Kingdom. It is important to note that the study did not involve all engineering technical workforce occupations, as the 'engineering industry' only includes establishments within the scope of the EITB. It excludes civil engineering establishments, government establishments and foundry establishments.

The authors reported difficulty in classifying the technical workforce jobs, commenting:

> One of the most important features of the technician category which makes any classification of jobs within it extremely difficult, is the wide diversity of jobs covered by the term 'technician' and the many areas in companies where technicians have a role to play.
>
> (Connor, 1983e, part 5, p. 8)

The researchers used a judgemental method of classification allocating respondents to various job groups based on their job descriptions, their range of activities and their job titles.

The study identified 21 main types of job, and each of these was grouped under one of five categories. The five categories and

21 job types are listed in Table 3.7, together with the percentage distribution of the jobs in the sample.

TABLE 3.7 ENGINEERING TECHNICAL WORKFORCE JOBS AND THEIR PERCENTAGE DISTRIBUTION (FROM CONNOR (1983e), THE TECHNICIAN IN ENGINEERING, PART 5, P. 8)

JOB TYPE	PERCENTAGE (n = 833)
Draftsmen, technical specialist and R D & D related jobs (36%)	
Design draftsmen	14
Detail draftsmen	8
Laboratory technicians and technical (e.g. metallurgists, chemists, laboratory technicians, weights or stress engineers)	7
Design engineers	4
Development engineers	3
Manufacturing related jobs (25%)	
Production and planning engineers/technicians	13
Installation and commissioning engineers	4
Maintenance engineers/technicians	3
Software jobs, e.g. NC programmers	3
Other manufacturing jobs	3
Test area jobs (18%)	
Test engineers/technicians and standards engineers	9
Inspectors	5
Quality and reliability engineers	4
Customer and supplier related jobs (14%)	
Contracts engineers	5
Service engineers	4
Estimators	3
Technical sales engineers	1
Supplier related jobs	1
Central service jobs (7%)	
Work study engineers	4
Technical authors, writers and illustrators	2
Other miscellaneous jobs	2
TOTAL:	100

The presentation of the data is somewhat confusing in part 5 of the EITB report, because in some cases the 21 job types are consolidated into 12 job groups (e.g. Tables 3.2 and 3.3 in the EITB report), in other cases 13 job groups (e.g. Table 3.4), in other cases 8 job groups (e.g. Tables 4.1 and 4.9) and in other cases 9 job groups (e.g. Tables 4.2, 4.3 and Figures 4.1 to 4.9). This variation makes some comparisons difficult or impossible. Nevertheless a large amount of interesting and useful data are reported on the types of job groups, their activities and their skill requirements.

The 833 respondents were questioned on each of 48 job 'activities', arranged in 7 main groups. They were also

questioned on the 'skills needed and knowledge required' in 28 areas arranged in 4 main groups. It was found that 'information and communication activities' was the job activity group ranked highest in frequency. Of the 833 respondents, 98% carried out at least one activity in this group. A similar result was obtained in the present study (see Chapter 6). The percentages for each of the seven activity groups are listed in Table 3.8.

TABLE 3.8 PERCENTAGE OF ENGINEERING TECHNICAL WORKERS WHO CARRIED OUT AT LEAST ONE ACTIVITY IN EACH GROUP (FROM CONNOR (1983e), THE TECHNICIAN IN ENGINEERING, PART 5, P. 15)

ACTIVITY GROUP	PERCENTAGE
Information and communication activities	98
Measurement or calculation of physical characteristics	93
Customer and supplier related activities	85
Design and drawing activities	76
Test and inspection activities	70
Manufacturing related activities	60
Computer related activities	32
TOTAL NUMBER OF RESPONDENTS:	833

Some of the other key results of the EITB study follow:

- the average age of the engineering technical workforce was estimated to be approximately 36 years, the largest age group being the 25 to 34 year old age group which comprised 33% of the engineering technical workforce;

- the percentage of female technical workers is estimated to be quite low, being 2.3% but there has been a fairly steady increase since 1971, when the percentage was 1.8%;

- there has been a trend of a steady increase in the percentage of engineering technical workers in the total engineering industry workforce, rising from 7.4% in 1976 to 8.3% in 1981 (with a provisional estimate of 8.7% in 1982);

- engineering technical workers tend to be concentrated in large establishments, particularly those of over 1000 employees.

- engineering technical workers also tend to be concentrated in electronic industries involved with new technology, and in industries requiring more than an average amount of drafting and design work.

A survey was conducted by the Technical Education Division of the Education Department of Western Australia in 1976 and 1977 (Cochrane, 1977). The study was discussed in Section 3.2, and is of interest here because it was concerned with the full range of engineering technical workforce occupations, although it concentrated on educational qualifications and attitudes to the TAFE Diploma in Engineering. The report of the study was entitled A Report on the Survey of Industry Needs for Engineering Courses at the Technical and Further Education Level and was released in 1977.

The survey involved interviews with 87 employers and 95 employees, the employees being identified as engineering technical workers.

TABLE 3.9 NUMBER OF EMPLOYEES IN EACH OCCUPATIONAL CATEGORY (SOURCE: COCHRANE, 1977, P. 19)

	NUMBER OF EMPLOYEES (PERCENTAGE OF ALL EMPLOYEES IN BRACKETS)		
Category	Private Organisations (n = 49)	Government Organisations (n = 36)	TOTAL (n = 85)
Engineers	502 (2.6)	587 (2.8%)	1089 (2.7%)
Engineering technical workers	474 (2.4%)	1547 (7.4%)	2121 (5.0%)
All employees	19362 (100%)	20789 (100%)	40151 (100%)

The employer survey provided some particularly interesting data on the numbers of employees in different categories, although some important aspects were not discussed in the report. The 87 organisations involved in the employer survey comprised 50 private industry firms and 37 government departments or statutory authorities. Because of incomplete data, some results from one private and one government organisation were discarded. Data on the number of employees in each occupational category are presented in Table 3.9.

Two important results derive from the data in Table 3.9. Firstly, engineering technical workers are clearly concentrated in government organisations rather than private organisations. In the employer survey, 77% of engineering technical workers were found to be in government organisations and 23% were found to be in private organisations. Secondly, the overall ratio of engineering technical workers to engineers varies significantly between private and government organisations. For private industry, the ratio is 0.9:1; for government organisations, the ratio is 2.6:1. Overall the ratio is 1.9:1. Similar results were found in other Australian studies, including the present study.

Employers in the Western Australian study were also asked to indicate the numbers of engineering workers employed on each of ten major work functions. The functions mentioned below were nominated much more frequently than the remaining eight functions:

- design and drafting;
- plant installation and maintenance (Cochrane, 1977, p. 18)

Another Australian study concerned with the full spectrum of engineering technical workforce occupations of much interest here is the Kinhill Stearns study for the National Training Council entitled The Private Sector Engineering Technical Workforce in Australia (1985). At the time of writing, the report of this study was still only in draft form, so the results reported here should be regarded as tentative.

The Kinhill Stearns study was restricted to the private sector only. If Western Australia is representative of the whole of Australia, it appears that the private sector employs only about a quarter of the engineering technical workforce (see Table 3.9). As discussed earlier, there is a substantial difference in the ratio of technical workers to engineers between the public sector and the private sector.

The Kinhill Stearns study undertook two main surveys:

- an employer survey, sampling 78 firms;
- a technical worker survey, sampling 418 technical workers.

Both surveys sampled the three States of Victoria, New South Wales and South Australia. Some of the key findings are:

- the 78 employers reported a total of 5261 technical workers in their firms, of which 2.7% were females (Kinhill Stearns 1985, pp. 11-12);

- the ratio of technical workers to professionals was 1.1 : 1, and the ratio of technical workers to tradespersons was 1 : 2.2 (p. 13);

- for the sample of 418 technical workers, their average age was about 36 years (the largest group being the 35 to 39 year-old group), the salary range group having the highest frequency was $20,000 to $25,000, and 5% were females (pp. 15-16);

- for the sample of 418 technical workers, the average time spent in their present job was 6.6 years, and the average time spent in engineering occupations was 17.8 years (p. 16).

The Australian Bureau of Statistics has published 1981 Census data (ABS, 1983). Question 27 in the 1981 Census asked respondents to describe each person's main job. Thus the statistical data on occupations is based on each person's self-description of his/her occupation and subsequent classification by ABS staff. In some cases the occupational classification was assisted by the individual's educational qualifications (ABS, 1982, p. 2).

Engineering technical workforce occupations were classed by the ABS as occupations within the minor group 'Draftsmen and Technicians, NEC', NEC being the abbreviation for 'not elsewhere classified'. Thirteen occupations were identified in this minor group (ABS, 1982, p. 12). Using our definition of the engineering technical workforce (see Section 2.1), six of these occupations were judged to be primarily engineering technical workforce occupations, these being:

- Draftsmen and Tracers (Code 066)
- Civil Engineering Technicians (Code 068)

- Electrical and Electronic Engineering Technicians (Code 069)
- Mechanical Engineering Technicians (Code 070)
- Mining Technicians (Code 073)
- Engineering Technicians, NEC (Code 074)

The 1981 Census revealed that a total of 68,092 people were employed in these six occupations in Australia. The distribution of the labour force by occupations and sex is shown in Table 3.10.

TABLE 3.10 CROSS-TABULATION OF EMPLOYEES BY ENGINEERING TECHNICAL WORKFORCE OCCUPATION AND BY SEX, FROM THE 1981 CENSUS

OCCUPATION	MALES	FEMALES	FEMALE%	PERSONS	PERSONS% OF TOTAL
DRAFTSMEN & TRACERS	27973	5245	15.8	33218	48.8
CIVIL ENG. TECHN.	7744	330	4.1	8071	11.9
ELECTRICAL/ELECTRONIC T.	15865	253	1.6	16118	23.7
MECHANICAL ENG. TECHN.	3751	67	1.8	3819	5.6
MINING TECHN.	605	49	7.5	653	1.0
ENG. TECHN. NEC	5627	587	9.4	6213	9.1
TOTAL:	61565	6531	9.6	68092	100.0

Source: Australian Bureau of Statistics 1981 Census of Population and Housing, Table 74, 1983.

NOTE:
1. Each cell in this table has been slightly randomly adjusted by ABS to avoid the release of confidential data. Totals may be slightly more or less than the sum of their components.
2. Component percentages may total slighty more or less than 100 because of rounding of component percentages.

Table 3.10 also indicates significant variation in the proportion of females among the six occupations. Similar results were found in other Australian studies and the present study (see for example Cochrane 1977, p. 17; Kinhill Stearns, 1985, p. 11).

The remaining seven occupations were judged to be primarily non-engineering, although it is likely that some engineering technical workers could be classified in some of these occupations. These seven occupations are:

- Physical Science Technicians (Code 067)
- Chemical Engineering Technicians (Code 071)
- Metallurgical Technicians (Code 072)
- Medical Science Technicians (Code 075)
- Life Sciences Technicians, NEC (Code 076)
- Veterinary Assistants, Technical (Code 077)
- Pharmaceutical Assistants, Technical (Code 078).

The 1981 Census revealed that a total of 41,008 people were employed in these seven occupations in Australia, and the total number classifed in the minor group 'Draftsmen and Technicians, NEC' is 109,100 people.

Table 3.11 RECENT MAJOR OCCUPATIONAL ANALYSIS STUDIES CONCERNED WITH A BRANCH OF THE ENGINEERING TECHNICAL WORKFORCE AND A PARTICULAR STATE OF AUSTRALIA

BRANCH OF ENGINEERING	STATE	STUDY
Mechanical	New South Wales	Brady, 1980
	New South Wales	Brady, 1981
Electrical, Electronic	New South Wales	DTAFE NSW, 1978
	South Australia	Hinkins, 1981
	South Australia	Parkinson, 1983
	Queensland	Knobel, 1985
Civil, structural, surveying and related	New South Wales	Salasoo, 1980
	Victoria	Peters, 1981 a
	Victoria	Peters, 1981 b
	Victoria	Malley et al., 1982
	South Australia	Brown, 1983
Drafting	New South Wales	Neilson et al., 1982
	New South Wales	Naylor, 1982
Other branches	Victoria	TDDEV, 1975
	New South Wales	Grannall, 1982
	New South Wales	McGee & Piterans, 1983

As the 1981 Census occupational categories do not closely coincide with the definition of the broad category of the engineers technical workforce used in the present study, caution should be exercised in comparing the Census data with data from the present study. The 1981 Census does not provide an estimate of the size of the engineers technical workforce in Australia for the same reason.

In Australia and overseas there have been a number of narrower occupational studies conducted in a particular geographic area for a single branch of engineering.

A good example is the New South Wales TAFE study (Salasoo, 1980) of the job functions of the civil engineering, structural engineering and materials testing technical workforce occupations. A list of the recent major studies of this type is given in Table 3.11. Such studies have provided useful detailed information on industry needs for curriculum developers in TAFE and Training Authorities in Australia. Although many of these studies are relevant to aspects of the present study, a review of each of these studies is not provided here. However, the results of some of these studies will be compared with relevant results of the present study in Chapters 5 and 6.

3.5 CODAP OCCUPATIONAL ANALYSIS METHODOLOGY

Occupational analysis usually involves determining the duties or tasks performed by a group of workers performing similar jobs. The term is usually distinguished from the narrower term 'job analysis', as job analysis often concentrates on studying the duties or tasks performed by an individual worker.

Occupational analysis has a variety of applications, but the major applications of interest in this study are those of education and training needs, job classification, and career paths.

CODAP (Comprehensive Occupational Data Analysis Programs) methodology was primarily developed within the United States Air Force and has been applied in occupational studies in the defence services in the United States, Australia and other countries for many years. It is a well developed methodology that has been extensively tested and validated.

Whereas CODAP refers specifically to a suite of 50 computer programs, the term is also used to describe the associated data gathering methods. These methods involve a survey using a task inventory.

CODAP is very useful when a detailed analysis of the work of 50 or more workers is required. A CODAP study will:

- find what job groups exist, each job group consisting of workers having similar job profiles;
- provide a job profile on each job group;
- provide a general profile on each job group on variables such as age, sex, job experience, education and location.

The CODAP method may be used for any occupation which may be broken down into a number of tasks. Thus it is particularly applicable to manual occupations, but may also be used for almost any technical, clerical or managerial occupation.

The task-inventory and the primary task factor

In Occupational analysis the essential information to be obtained is which tasks are performed and the relative contribution of each task in terms of its importance or length of performance.

Christal (1973, pp. 1-8) explains how the task-inventory is developed for each occupational survey and which rating scales should be applied to each task in the inventory. He and a number of other authors recommend relative time spent as the primary task factor rather than other factors such as frequency of performance. Christal (1973, pp. 7-8) states:

> I strongly recommend use of the relative time-spent scale as the primary rating factor in occupational surveys, and that the obtained values be transformed into percent time-spent estimates. This is a requirement for the CODAP system, and it makes possible many types of analyses which cannot be accomplished using frequency of performance data.

In recent years a number of researchers using CODAP methodology have used another scale, termed 'contribution to job'. The rationale for this scale is that for many occupations, and particularly those above base level occupations, the time-spent on a task is not the most pertinent measure. Some tasks may be very time consuming but relatively unimportant, whereas other tasks may require little time but be very significant in the overall performance of a person's job. For the contribution scale respondents are asked to consider factors such as the

importance and the time-spent on each task, and then rate the relative contribution to their job of each task. The relative contribution to job and the relative time-spent scales are similar types of scales. The concepts of 100% contribution for all tasks, and 100% time-spent for all tasks, are valid and meaningful. Thus, the ratings for individual tasks may be converted to percentages for either scale.

The initial CODAP program converts the relative contribution or time-spent ratings into percent contribution or time-spent for each respondent. Subsequent analyses, such as the computation of group contribution or time-spent and cluster analysis, are performed on these individual task percent values.

Cluster analysis by CODAP

A hierarchical cluster analysis procedure is used by CODAP to determine the occupational clusters based on similarity in task profiles. Unlike some other hierarchical cluster analysis procedures, the CODAP procedure does not increase the similarity index if two cases do not perform a particular task. This is an important desirable feature when large task inventories are used.

Archer (1966) describes in some detail the cluster analysis procedure used by CODAP. At the initial stage, each of the n respondents in the analysis is treated as a cluster containing one member. The 'average overlap between groups' is calculated for each pair of clusters. Later writers termed the average overlap between groups as the 'between groups overlap index'. The between groups overlap index measures the degree of similarity in the task profiles of a pair of clusters, and has a maximum of 100% and a minimum of 0%. In each clustering stage, the pair of clusters with the highest between groups overlap index is merged into a single cluster. Thus after the first stage, n-1 clusters remain. The overlap index for each pair of clusters containing the new cluster is then calculated. Again the pair of clusters having the highest index is merged into a single cluster, leaving n-2 clusters. This cycle is repeated until a single cluster containing all the respondents is formed.

As each new cluster is formed, the average overlap within the new cluster is computed. Later writers termed the average overlap within the cluster as the 'within group overlap index'. The within group overlap index measures the degree of similarity in the task profiles of the respondents in the cluster and has a maximum of 100% and minimum of 0%.

The 'diagram' printout showing the result of the cluster analysis by CODAP is in the form of a tree diagram (dendrogram). All clusters newly formed by the clustering program are shown in the diagram if they contain five (or any other predetermined minimum number) or more respondents. For each cluster the between groups overlap index and the within group overlap index are printed, and lines indicate the way in which each new cluster is formed from a pair of two smaller clusters. In the present study the diagram printout was quite large, so Figure 5.1 presents a simplified version.

Once the diagram printout is obtained the problem is to decide which, if any, of the clusters shown in the tree diagram represent significantly different job types. Archer (1966, p. 24) suggests what a suitable level of cluster homogeneity exists when the 'within group overlap index' is approximately 50% or higher and the 'between groups overlap index' is approximately 35% or higher. Clusters with lower indices are likely to be too heterogeneous to be called a single job type. However, Archer states that it is preferable to use these two indices only as

> .... tentative indicators of significant job types, and to consider additional information, such as the background characteristics of group members, before making final decisions. (1966, p. 24).

<u>The group job description</u>

Once the significant job types have been identified, a variety of analyses may be performed to obtain information on the task and duty profiles and other characteristics of each job type.

The task profile of a cluster is termed the 'group job description' by CODAP writers (Goody, 1982, p. 35). The group job description is an important product of CODAP analysis. It is computed from the individual job descriptions of all the respondents in the cluster. Alongside each task in the inventory three main items of information are given. These are:

- the percentage of members in the cluster that perform the task (percent performing);
- the percentage contribution or time-spent on the task by those members who perform it;
- the percent contribution or time-spent on the task by the cluster as a whole (overall percent contribution or time-spent).

The third value is obtained by simply multiplying the first two values together and dividing by 100. For example, suppose there are 200 respondents in a cluster and 150 of them perform a particular task; and for these 150 respondents the average percentage contribution of the task is 8%, the three values that will be given are:

- 75% of members in the cluster perform the task;
- the task contributes an average of 8% to the jobs of those members who perform the task;
- the task contributes an average of 6% to the jobs of all members of the cluster.

The group job descriptions of each occupational cluster provide the basic information required by vocational curriculum developers. The primary task factor information of percent performing the task and overall percent contribution or time-spent on the task establishes the 'onus of proof' for course content. If curriculum designers want to include a little-used skill, the onus is on them to show why resources should be allocated to teaching it. Conversely, if a skill is regularly used in the workplace, its omission from the curriculum should be justified (Goody, 1982, p. 33).

CHAPTER FOUR: METHODOLOGY

To achieve the research objectives, a national survey of the engineering technical workforce was conducted. The sampling frame and survey instrument were developed partly by interviewing representatives from industry, education and professional and para-professional associations.

4.1 SAMPLING

No single list of names and addresses adequately covered the population of engineering technical workers in Australia. The validity of this cluster analysis study depends on the comprehensiveness of the sample. All of the important groups or clusters of engineering technical workers need to be sampled to provide a complete analysis of the engineering technical workforce structure. A biased sample will have little effect on the cluster analysis, other than effect the relative sizes of the populations they represent. To ensure a comprehensive sample, a sampling frame using two sources was used as follows:

1. Employer sampling frame

- A list of firms likely to employ engineering technical workers was prepared from the yellow pages of telephone directories.

- A stratified random sample of the above list was selected, based on the stratum of State or Territory. The 1981 census statistics for engineering technical workforce occupations, as given in Table A-1 in Appendix A, was used to proportionally divide the sample strata.

- A preliminary mail survey of sampled firms was undertaken to determine size of engineering technical workforce within each firm and the names of employees willing to participate in the main survey.

- A sampling frame was constructed, based on results of the above preliminary survey.

2. TAFE/CAE student and graduate sampling frame

- Names and addresses of students enrolled in middle level engineering courses in TAFE and CAE colleges in Australia were obtained. To ensure a wide range in length of industrial experience, two cohorts were sampled:

  - graduates and students enrolled in all stages of a course in 1980,

  - graduates and students enrolled in all stages of a course in 1984.

- A stratified random sample of the above list was selected, based on the stratum of State or Territory. The 1981 census statistics for engineering technical workforce occupations, as given in Table A-1 in Appendix A, was used to proportionally divide the sample strata.

- A preliminary mail survey of the sampled students and ex-students was undertaken to determine the names of those who were willing to participate in the main survey.

- A sampling frame was constructed, based on results of this preliminary survey.

It was important to obtain a sample size of over 1,000 in the main survey to enable good coverage of the engineering occupations and a valid and stable cluster analysis.

Because of the characteristics of the sampling frame, a low response rate was expected for the preliminary survey. For example, the addresses for the 1980 students were 5 years out-of-date. To overcome this, a large initial mailing of about 5,000 was undertaken, and follow-up letters were sent to those on the industry list. Because of the confidentiality requirements in some States, follow-up letters could not be sent to those on the student list. Follow-up letters were also sent to those on the industry list in the main survey.

The preliminary survey was conducted in November 1984. A small pilot survey, using a draft of the main survey instrument, was conducted in January 1985. The final main survey was conducted in April 1985.

TABLE 4.1 PRELIMINARY SURVEY RETURNS

		Industry survey	Student survey	Totals
(a)	Number	2,523	2,820	5,343
(b)	Returned but not usable			
	• returned unopened	204	203	407
	• returned after deadline	11	5	16
(c)	Net (a-b)	2,308	2,612	4,920
(d)	Completed by deadline	1,089	1,090	2,179
(e)	Response rate (d/c)	47%	42%	44%

TABLE 4.2 MAIN SURVEY RETURNS

		Industry survey	Student survey	Totals
(a)	Number posted	1,109	712	1,821
(b)	Returned but not usable:			
	• returned unopened	(12)	(4)	(16)
	• returned blank	(17)	(4)	(21)
	• no to question 1	(30)	(28)	(58)
	• returned after deadline	(31)	(24)	(55)
	Total for (b)	90	60	150
(c)	Net (a-b)	1,019	652	1,671
(d)	Completed by deadline	773	457	1,230
(e)	Response rate (d/c)	76%	70%	74%

The resulting response rates overall were 44% in the preliminary survey and 74% in the main survey. Details of the returns are given in Tables 4.1 and 4.2.

4.2 SURVEY INSTRUMENTS

The preliminary survey instruments were primarily designed to obtain the names and addresses of those within the engineering technical workforce and who were willing to complete the more detailed survey. Copies of the preliminary student questionnaire and the preliminary industry questionnaire are given in Appendix B. Copies of the covering letters and follow-up letter are also given in Appendix B.

In both questionnaires, information on the field of engineering was sought. In the preliminary industry questionnaire, additional information on the number of engineering workers at each level was sought.

The purpose of the main survey was to obtain information on the respondents, their employing organisations, and the tasks that they performed in their jobs.

The main survey instrument was a mail questionnaire in the form of a 40-page booklet with covering letter. Copies of the booklet and covering letter are given in Appendix B. The booklet was composed of two main sections. The first section dealt with the background variables of age, gender, educational attainment, job title, job experience, size and location of firm, salary and other variables. The second section consisted of an inventory of work elements. This inventory was developed to satisfy the following criteria:

- it adequately covered the scope of work performed by the engineering technical workforce in Australia;

- items in the inventory differentiated workers in different occupational clusters;

- items in the inventory provided useful information to TAFE curriculum developers and some items specifically covered work involving computers and other items covered work involved in quality control;

- the work elements were constructed at a level of specificity to result in an inventory of between 500 and 1,000 elements;

- the work elements and their items conformed to CODAP methodology (Christal, 1973; Goody, 1982), and in particular the first word of each task was to be a verb.

The design of the whole questionnaire was influenced by two general factors. Firstly, although the nature of this research meant that the questionnaire was necessarily lengthy, it had to be easy to answer and not too time consuming. One way in which this was achieved was to arrange the tasks into small groups so that respondents were able to skip whole groups of tasks. Secondly, it had to allow straightforward keypunching and data checking.

The inventory of tasks was developed by a panel of six experts, each of whom was familiar with engineering technical work in a major branch of engineering. The panel of experts was given the above criteria. They undertook the development as individuals, and, towards the end of the development phase, worked as a group with the researcher to ensure consistency in style and to avoid duplication.

After the development of the task inventory a draft of the main survey instrument was prepared. This was circulated to members of the project advisory committee and other interested persons for comment.

In addition, a pilot survey was undertaken using the draft survey instrument. The intention of this pilot study was to identify any difficulties or shortcomings in the survey instrument. A particular objective of the pilot survey was to ensure that the inventory of tasks adequately covered the work of the engineering technical workforce. The last section of the pilot survey instrument sought general information on the coverage of the task inventory, the clarity of the questions, and the time taken to complete the questionnaire. A sample of 30 respondents was used, and ten of the respondents (from New South Wales, Victoria, and South Australia) were subsequently interviewed to obtain more specific information.

The comments from the Advisory Committee, the data from the pilot survey, and the interviews each provided very useful information, and this information helped to shape the final version of the main survey instrument. In particular, the task inventory was expanded from 596 tasks in 60 groups in the pilot survey to 621 tasks in 61 groups in the final survey. The new group was titled 'BA - other electronic devices' and consisted of 8 tasks. Overall, however, the final version of the main survey instrument was not substantially different from the draft version used in the pilot survey.

TABLE 4.3 THE DUTIES AND TASK NUMBERS IN SECTION B OF THE MAIN QUESTIONNAIRE

	Duty	No. of tasks
A.	Project planning and management	8
B.	General administration	15
C.	Written communication	11
D.	Oral communication	10
E.	Finance and estimating	8
F.	Purchasing	7
G.	Staff development	10
H.	Staff supervision	5
J.	Quality assurance/quality control	6
K.	Quality testing and measuring	14
L.	Materials testing	5
M.	Maintenance	10
N.	Safety	5
P.	Site inspection and investigation	14
Q.	Data collection and analysis	7
R.	Use of calculators and computers	12
S.	Computer and digital control equipment	12
T.	Computing systems	9
U.	Digital and computing hardware	17
V.	Computing software	10
W.	Engineering drawing and graphics	8
X.	Design drafting	12
Y.	Engineering survey drafting	7
Z.	Cadastral survey drafting	7
AA.	Electronic fabrication	6
AB.	Power generation, energy transfer and fluid flow	11
AC.	Electrical power generation, transmission distribution and utilization	27
AD.	Automatic control systems	20
AE.	Earth moving and mining	8
AF.	Motorised transport systems	9
AG.	Process plant engineering	10
AH.	Metal fabrication, turning and casting	11
AJ.	Wood, paper, plastics and packaging	11
AK.	Building services	13
AL.	Advisory and specialist services	14
AM.	Construction	11
AN.	Biotechnology and ergonomics	12
AP.	Tooling and equipment	12
AQ.	Materials handling	6
AR.	Production engineering	9
AS.	Work study	8
AT.	Fluid power	10
AU.	Electrical instruments and sensors	11
AV.	Power electronic devices	11
AW.	Electrical protection devices, relays and contactors	14
AX.	Power transformers, circuit breakers and isolators	17
AY.	Electrical drives	18
AZ.	Electronic communication	8
BA.	Other electronic devices	8
BB.	Engineering surveying	10
BC.	Cadastral surveying	4
BD.	Hydrographic surveying and drawing	10
BE.	Survey computations	7
BF.	Civil design and computations	11
BG.	Structural design and computations	8
BH.	Hydrology and hydraulics	9
BJ.	Town planning	8
BK.	Cartography	7
BL.	Air photo and map interpretation	10
BM.	Survey investigation and searching	8
BN.	Still and movie photography	5
Total tasks		621

For the purpose of this study, the work elements in the inventory were called 'tasks'. There were a total of 621 tasks in the inventory. These were arranged into groups called 'duties'. There were 61 duties in the inventory, and these are listed in Table 4.3. During the analysis phase of the project, the 61 duties were arranged into four groups called 'areas', to assist in interpretation of results. These four areas were not indicated on the survey instrument.

A 7-point rating scale of 'contribution to your job' was used for each of the 621 tasks in the inventory. Respondents were asked to consider the overall contribution that their performance of the task makes to their job. They were instructed that the contribution rating should be influenced equally by two factors:

- amount of time spent on the task;
- importance of the task.

Instructions on how to rate the contribution of each task were given at the start of Part B on Page 7 of the questionnaire. In addition, the rating scale was reproduced frequently throughout the succeeding pages of the task inventory.

The 'contribution to job' scale was used instead of the more common 'time-spent' scale because it was considered to be more appropriate in this study. In engineering work, tasks may consume relatively little time yet contribute relatively much to the overall job of the technical worker. Relative contribution is the variable of more interest to curriculum designers.

4.3 DATA ANALYSIS

Simple statistics were obtained from the preliminary surveys.

The main survey data were analysed by various programmes within CODAP (Comprehensive Occupational Data Analysis Programmes). While many of the CODAP analyses parallel analyses performed by programmes within other statistical computer packages such as SPSS and GENSTAT, the CODAP analyses provided a good format as well as greater detail.

The key part of the analysis was the cluster analysis. This sorts the sample of respondents into groups or clusters, based on their similarity in tasks performed.

After the clusters were determined, the characteristics of each cluster were analysed to give:

- task and duty profiles;
- profiles on background variables (e.g. age, gender, salary, education).

Some frequency cross-tabulations on field of engineering by other background variables were also performed.

The existence of two levels within the engineering technical workforce was tested by checking for relationships between:

- highest education and 'task level index';
- highest education and number of tasks performed.

The correlation between these two pairs of variables were calculated and the significance levels determined.

Task level index was measured by firstly obtaining for each of the 621 tasks, an average task level rating on a 1 to 7 scale as follows:

7 - task always performed by upper middle level technical workers (or professional engineers)

6 - task mostly performed by upper middle level technical workers (or professional engineers)

5 - task performed by upper middle level technical workers more often than lower middle level technical workers

4 - task performed about equally by upper and lower middle level technical workers

3 - task performed by lower middle level technical workers more often than upper middle level technical workers

2 - task mostly performed by lower middle level technical workers (or tradespeople)

1 - task always performed by lower middle level technical workers (or tradespeople)

The average ratings were calculated from the ratings of a panel of ten experts who were familiar with engineering associate level and technician level occupations. There was a reasonably good level of agreement among the ten raters.

These average ratings were then rescaled to give a 0 to 1 range. The task level index for each cluster was calculated by summing the products of the rescaled task ratings and the overall contribution to job percentages, over the 621 tasks in the inventory. The theoretical range of the task level index is 0 to 100.

Task level index was calculated to give an indication of the average level, of tasks performed, based on the model represented in Figure 3.1 and the assumption of two levels within the engineering technical workforce.

CHAPTER 5: PRELIMINARY SURVEY RESULTS

The main purpose of the preliminary surveys was to obtain the names and addresses of engineering technical workers who were willing to participate in the subsequent main survey. Some additional useful information was obtained, including the field of engineering of the respondent and, in the case of the preliminary industry survey, the distribution of employees among four engineering occupational categories. These results are presented in the following sections.

TABLE 5.1 DISTRIBUTION OF RESPONDENTS IN DIFFERENT FIELDS OF ENGINEERING

Field	Prelim. student survey no. resp.	Prelim. industry survey no. employers*
Electronic	151	122
Electrical	122	223
Mechanical	144	386
Production	35	120
Work study/methods	3	20
Structural	19	284
Materials testing	12	81
Civil	60	386
Surveying	31	142
Mining	8	61
Automotive	51	102
Other field	107	122
Unusable	44	-
TOTAL:	787	2 030

*Note: In the preliminary industry survey, employers could nominate more than one field of engineering.

5.1 FIELD OF ENGINEERING

Table 5.1 gives the distribution of respondents in different fields or branches of engineering. Differences in the distribution between the preliminary student survey and preliminary industry survey were expected because of the different sampling frames, and the fact that multiple responses on the 'field of engineering' question were allowed in the preliminary industry survey, while only one response was allowed in the preliminary student survey.

The distribution of respondents in different fields of engineering in the main survey is discussed in Section 6.2.

5.2 ENGINEERING OCCUPATIONAL CATEGORIES

Question three in the preliminary industry survey asked respondents to indicate the number of engineering workers in their organisation in each of four categories:

- professional engineer or surveyor
- engineering technical worker
- tradesperson
- apprentice.

TABLE 5.2 NUMBER OF ORGANISATIONS CROSS-TABULATED ON NUMBER OF ENGINEERING EMPLOYEES BY CATEGORY

No. employees	Professional	Technical	Trade	Apprentice
0	415	393	468	634
1	138	109	54	121
2-5	238	246	181	184
6-10	123	17	114	51
11-20	82	87	89	23
21-50	40	64	73	26
51-100	20	23	29	16
100-200	8	10	31	5
200-1,000	15	21	26	12
over 1,000	1	6	10	2
Minimum	0	0	0	0
Maximum	1 470	4 540	4 690	1 705
No. responses	1 079	1 076	1 075	1 074
Total no. employees	14 515	28 187	46 194	11 675
Mean no. employees	13.5	26.2	43.0	10.9

It was expected that our sampling procedure would involve contacting some organisations that employed no engineering staff. Of the 1089 respondents, 118 indicated no engineering staff employed in all four categories. These 118 cases were excluded from the analysis.

Table 5.2 gives the number of organisations cross-tabulated on number of engineering employees by category for the organisations responding in the preliminary industry survey. A high proportion of organisations had one or two employees in only one of the levels and no employees in the other levels, and this was reflected in the relatively large numbers of organisations having no employees in the four categories (first row of Table 5.2). A small number or organisations had very large numbers of employees in each level, and this had a significant effect on the mean number of employees at each level. Overall, there are most employees at the trade level (mean = 43.0).

Table 5.3 gives the number of organisations cross-tabulated on number of professional engineers by number of engineering technical workers. The table indicates that 140 organisations had no professional or technical workers in engineering (but must have had at least one trade or apprentice worker).

The pattern of frequencies in this table indicates that in small, medium and large organisations, the number of employees in technical levels is generally about the same or higher than the number of employees at professional levels of engineering. A further trend apparent in Table 5.3 is that large organisations tend to have higher ratios of engineering technical workers to professional engineers compared with small organisations.

TABLE 5.3 NUMBER OF ORGANISATIONS CROSSTABULATED ON NUMBER OF PROFESSIONAL ENGINEERS BY NUMBER OF ENGINEERING TECHNICAL WORKERS

Technical	0	1	2-5	6-10	11-20	21-50	51-100	100-200	200-1000	over 1000	Total
Professional											
0	140	50	70	17	13	3	0	0	2	0	295
1	69	29	28	8	0	1	1	0	0	0	136
2-5	39	26	106	42	15	5	1	1	1	0	236
6-10	14	4	29	35	24	16	1	0	0	0	123
11-20	4	0	10	13	29	20	5	1	0	0	82
21-50	5	0	1	2	4	15	6	2	4	0	39
51-100	2	0	0	0	2	2	7	3	4	0	20
100-200	0	0	0	1	0	1	2	1	3	0	8
200-1000	0	0	0	0	0	0	0	2	8	4	14
over 1000	0	0	0	0	0	0	0	0	0	1	1
Total	273	109	244	118	87	63	23	10	19	5	954

Table 5.3 also indicates that the ratio of engineering technical workers to professional engineers varies widely among the different employers. For example, two organisations indicated 51 to 100 professional engineers and <u>no</u> engineering technical workers. On the other hand, another two organisations indicated 200 to 1000 engineering technical workers and <u>no</u> professional engineer. This point should be borne in mind when examining <u>whole sample</u> ratios. In addition, other studies indicate that there may be a big difference between the public sector and the private sector in the average ratio, with the public sector tending to have a higher ratio of engineering technical workers to professional engineers (see Section 3.4).

For the preliminary industry survey, <u>whole sample</u> ratios are given in Table 5.4. These ratios are simply computed from the mean number of employees per organisation in each category, as given in Table 5.2.

TABLE 5.4 WHOLE SAMPLE RATIOS OF EMPLOYEES IN EACH CATEGORY

Ratio	Value
Technical workers:professionals	1.9 :1
Tradespersons: technical workers	1.6 :1
Apprentices:tradespersons	0.25:1

The 1.9:1 ratio of technical workers to professionals is the same as that found in the Education Department of Western Australia study (Cochrane, 1977). The three ratios differ though from those found in the Kinhill Stearns (1985) study. It is strongly suspected that the differences are mostly attributable to differences between the public and private sector, as the Kinhill Stearns study only sampled the private sector.

CHAPTER 6: MAIN SURVEY RESULTS

The main survey obtained a net national sample of 1,230 engineering technical workers, and its purpose was to identify the main occupational groups and their characteristics.

This chapter presents the results of this survey. The key result was obtained from the cluster analysis of the sample, and this is presented in the first section. In subsequent sections, the background information and job functions of each group is discussed, progressing from the whole sample (representing the engineering technical workforce) to the minor clusters as follows:

whole sample

major clusters

intermediate and primary clusters

The intermediate and primary clusters within each of the four major clusters are dealt with in separate sections.

6.1 CLUSTER ANALYSIS RESULTS

The most important part of the analysis of the main survey data is the cluster analysis.

When interpreting the result of the cluster analysis, four things should be borne in mind. Firstly, the clustering is based on the similarity of task contribution ratings (Section B of questionnaire). Thus, two respondents who perform somewhat similar tasks are likely to be in the same cluster, irrespective of possible differences in their background characteristics such as age, education and size of employer.

Secondly, clusters were only included in subsequent analysis if they contained five or more members.

Thirdly, the primary clusters at the bottom of the cluster diagram were only included in subsequent analysis if they had a within group overlap index (a measure of cluster homogeneity) of 40% or more and a between groups overlap index of 25% or more. Most of the primary clusters had a within group overlap index of 50% or more. Those having within group indices of 40 to 45% and/or between groups indices of 25 to 30% should be regarded as marginal, and are indicated by an asterisk (*) in Tables 6.4, 6.5, 6.6 and 6.7.

Fourthly, interpretation of the nature of each occupational cluster may be based on all of the information available from analysis of the survey, and this includes the duty profiles, task profiles and profiles on background variables. The titles assigned to each occupational cluster in this study are descriptive and have no industrial or legal status. The titles have been assigned on the basis of the job profile of each cluster.

In Section 3.5 the clustering process was described in general terms. When examining the clusters obtained in this study, it will be usefull to distinguish five types of cluster, obtained at different stages in the clustering process as follows:

whole sample cluster (n = 1)

⇧

major clusters (n = 4)

⇧

intermediate clusters (n = 45)

⇧

primary clusters (n = 99)

⇧

individual respondent clusters (n = 1230)

In this study the 1230 respondents formed 1230 individual respondent clusters at the first stage of the clustering process. In subsequent stages, the clusters combined to form larger clusters, until a single whole sample cluster, containing 1230 members, was formed. The cluster diagram shows all of the clusters except the individual respondent clusters.

NOTES: 1. The number at the top of each box or circle is the 'cluster number' which has been assigned during the clustering process. The numbers in parentheses refer to the number of respondents in each cluster.
2. Only the larger clusters are shown in this summary.

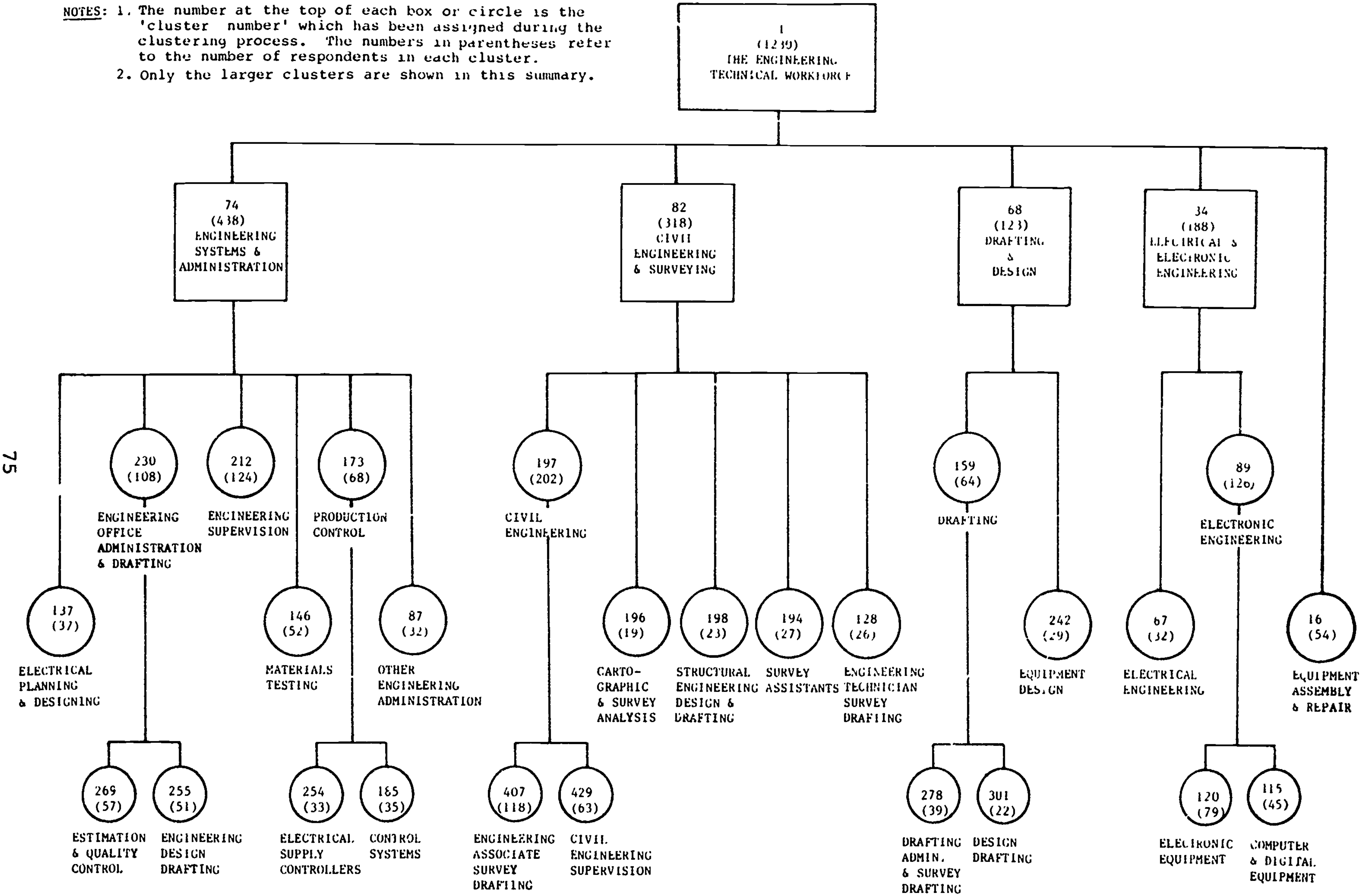
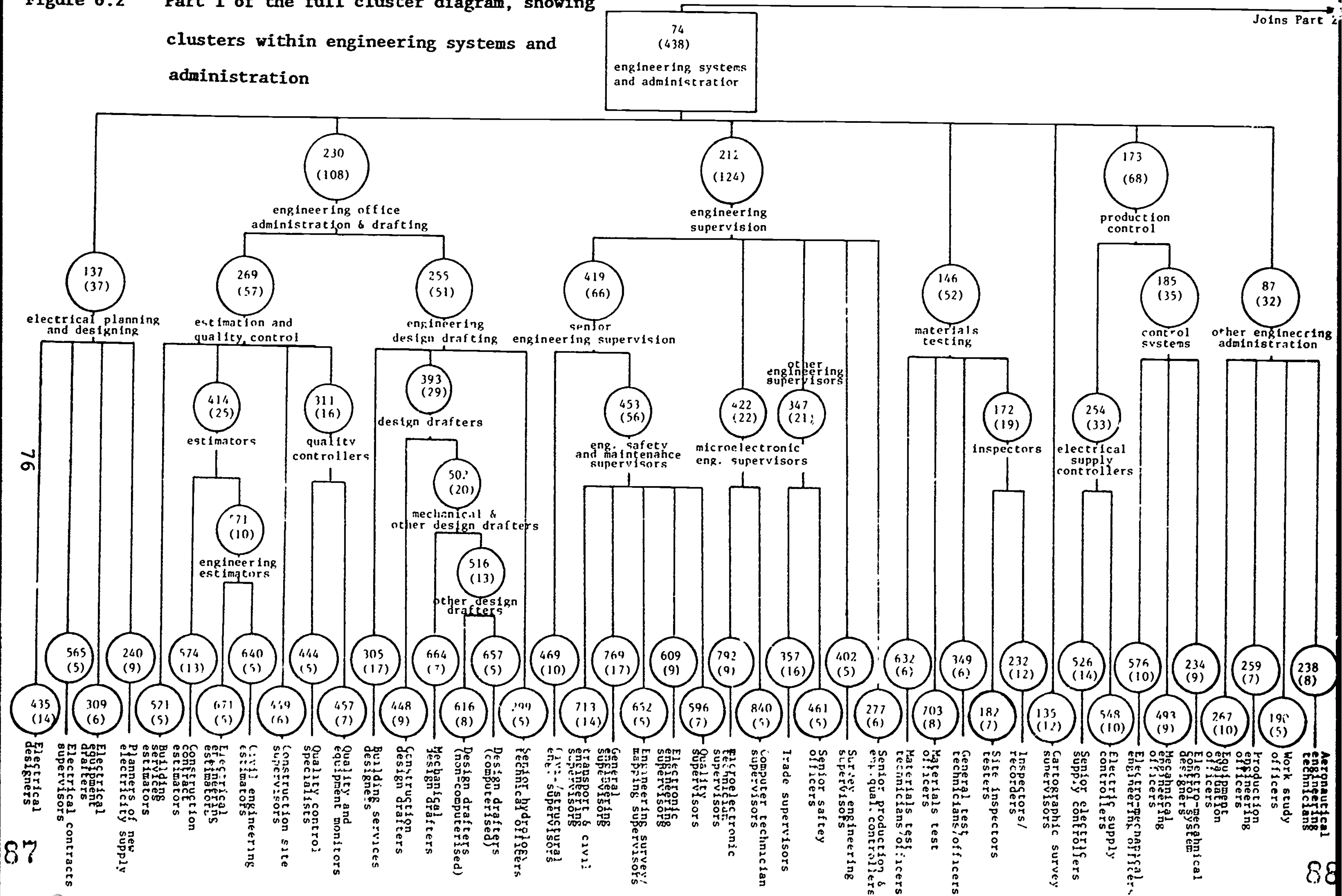


Figure 6.1 Summary of the cluster diagram

Figure 6.2 Part 1 of the full cluster diagram, showing clusters within engineering systems and administration



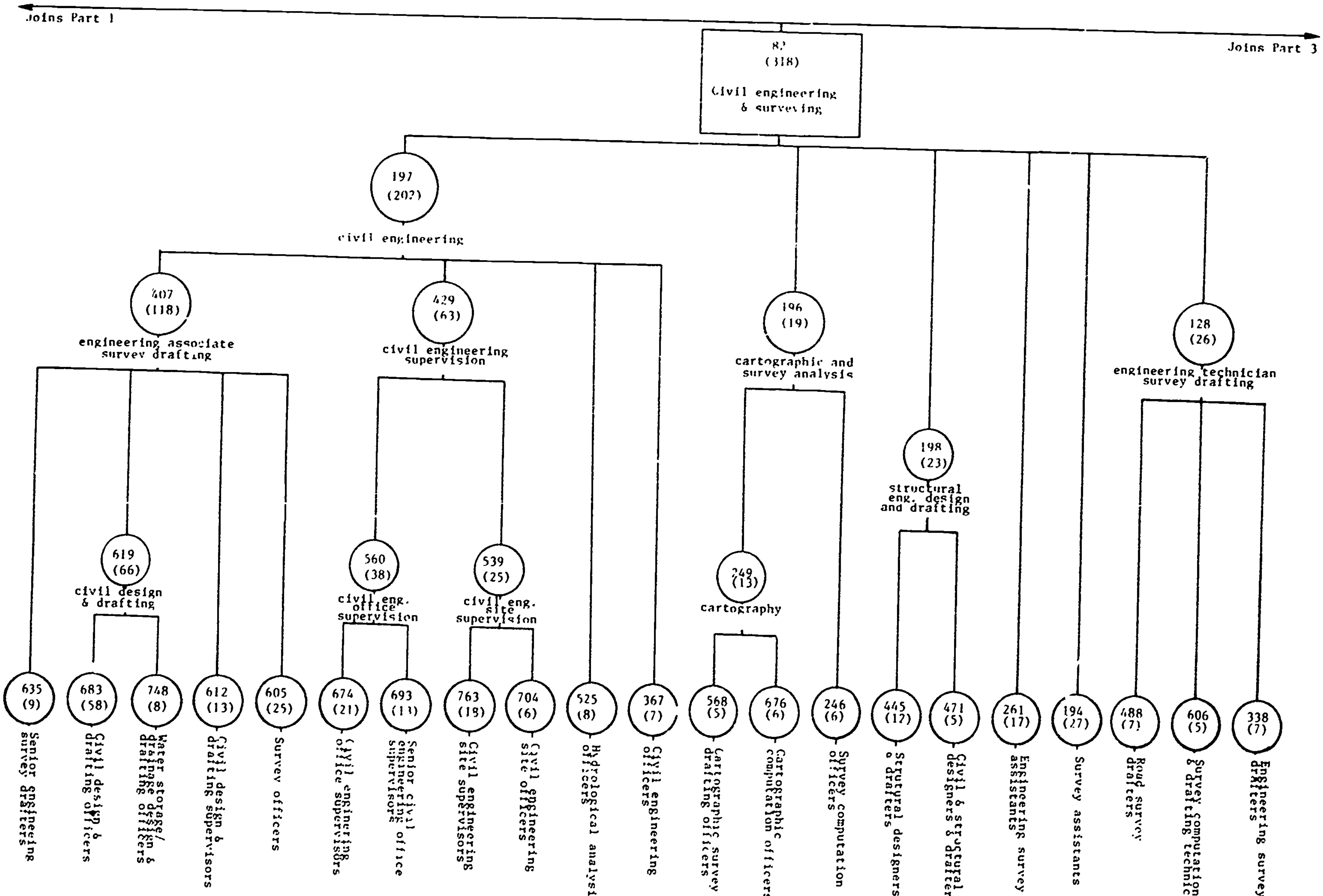


Figure 6.3 Part 2 of the full cluster diagram, showing clusters within civil engineering and surveying

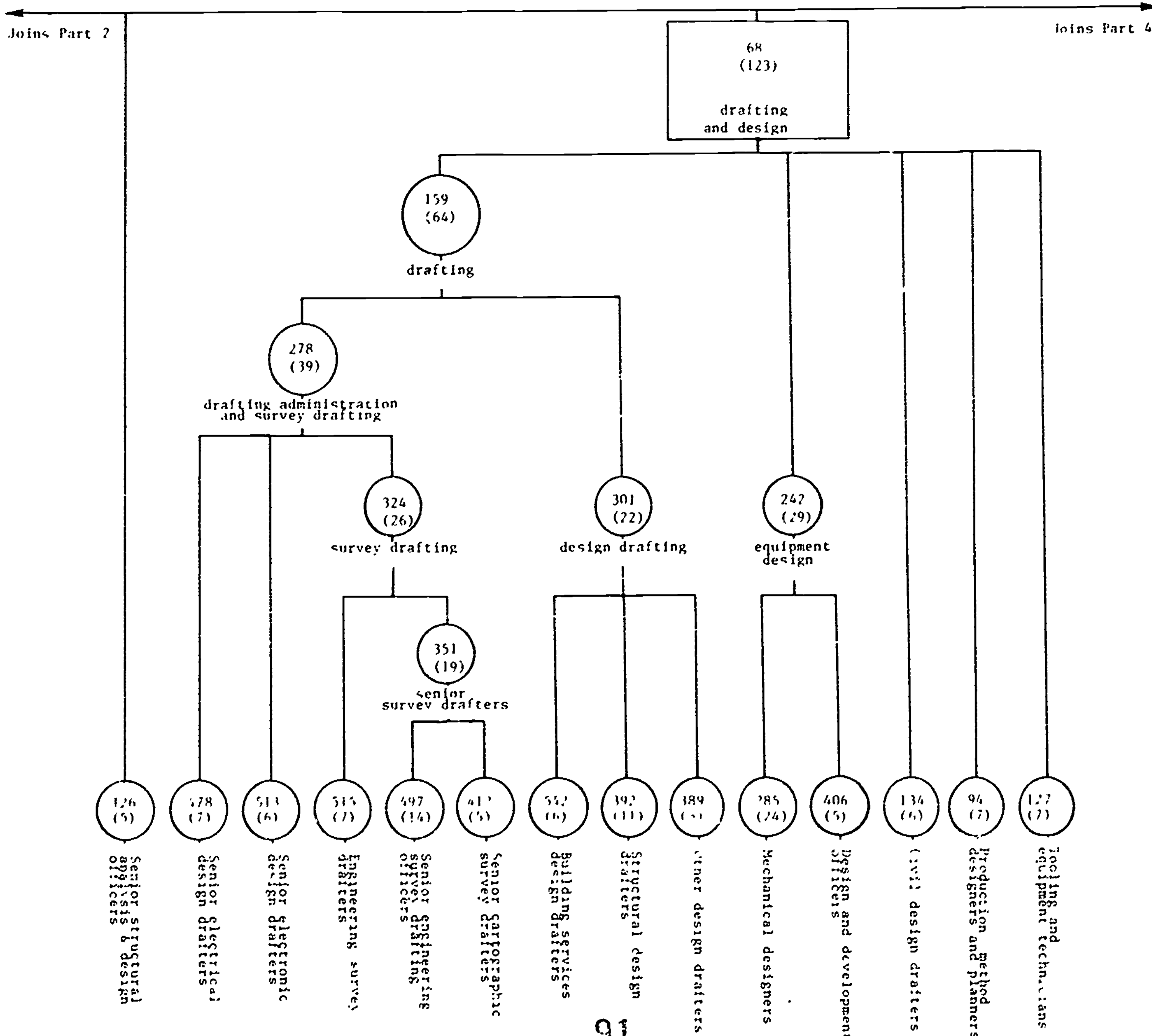


Figure 6.4 Part 3 of the full cluster diagram, showing clusters within and near drafting and design

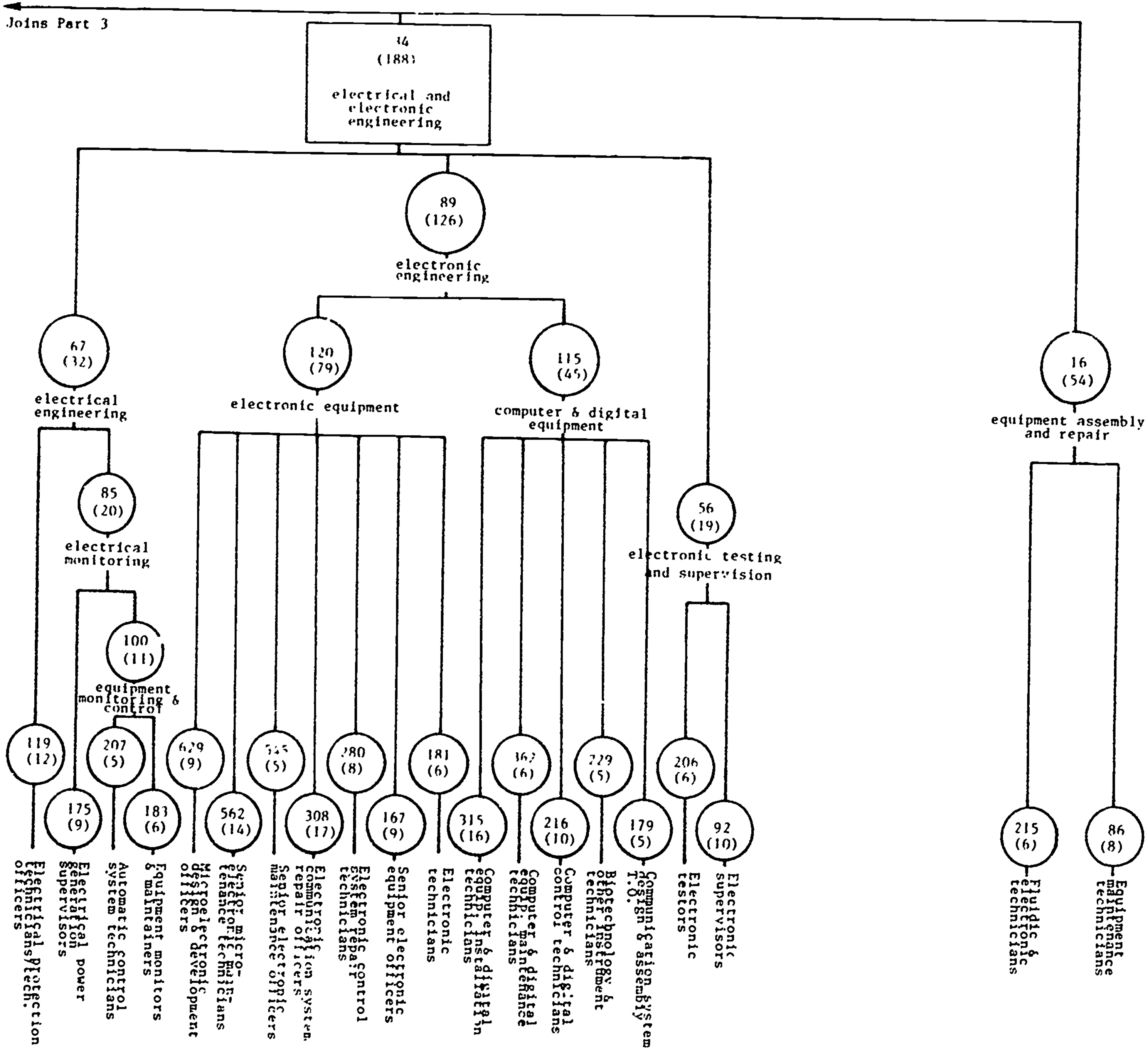


Figure 6.5 Part 4 of the full cluster diagram, showing clusters within and near electrical and electronic engineering

Cluster diagram summary

The result of the cluster analysis is summarised in Figure 6.1, giving the four major clusters and important intermediate clusters. The full cluster diagram has been divided into four parts because of its large size, and is given in Figures 6.2, 6.3, 6.4 and 6.5.

Each box or circle in the cluster diagram represents a cluster of five or more respondents. The number at the top of each box or circle is an arbitrary number assigned during the clustering process, and is called cluster number or group number The number in brackets indicates the number of respondents within that cluster.

The cluster diagram is a two-dimensional tree diagram, useful for showing the primary relationships between clusters. For each cluster, the immediate neighbouring clusters are similar in job profile. As the analysis is multidimensional rather than two-dimensional, it is quite possible that a cluster near the far left of the diagram may have a somewhat similar job profile to a cluster near the far right.

The vertical position in the diagram indicates the approximate degree of similarity <u>within</u> each cluster. A cluster at the bottom of the dendrogram has high within group similarity. In other words, members of such a cluster tend to be homogeneous in their job profiles. A cluster near the top of the dendrogram has low within group similarity. In other words, members of such a cluster tend to be heterogeneous in their job profiles.

Clusters linked directly by vertical lines to a cluster above in the diagram are sub-sets of that cluster above it.

Primary clusters

The primary clusters are shown at the bottom of the full cluster diagram (Figures 6.2 to 6.5) and, as stated before, are only shown in the diagram if they contain five or more members and have a within group overlap index of over 40% and a between groups overlap index of over 25%. In this study, each primary cluster represents a distinct job type or occupational cluster within the engineering technical workforce. There were 99 primary clusters found in this study.

The job type of each of the 99 primary clusters was interpreted by referring to the duty and task profiles of the cluster. Further help in determining the nature of each cluster was obtained by referring to the background information on each cluster, particularly the information on average age, average salary and highest education.

It was found that each of the primary clusters was clearly interpretable, and consequently a discriptive title was given to each cluster.

Intermediate clusters

The intermediate clusters are shown above the primary clusters but below the major clusters. The intermediate clusters consist of two or more primary clusters, and are larger than most primary clusters. Each intermediate cluster represents a broad occupational category in the engineering technical workforce. There were 45 intermediate clusters found in this study.

The number of respondents in each intermediate cluster must be greater than or equal to the sum of the number of respondents in each primary cluster linked below it. In cases when the number in the intermediate cluster is higher than the sum, some individual outlying respondents have merged with the intermediate cluster at the intermediate stage of the clustering process.

The hierarchical pattern of the cluster diagram was meaningful and easy to interpret. This pattern provides useful guidelines for those planning courses for the engineering technical workforce. It suggests, for example, ways in which:

- mainstream courses may include more specialised options which meet the needs of one or more primary clusters;

- courses aimed at the needs of broad occupational categories (represented by the intermediate clusters) may be composed of curriculum modules, each module meeting the needs of a primary cluster.

Major clusters

The major clusters are shown near the top of the cluster diagram, and consist of two or more intermediate clusters. Four major clusters were found in this study:

- cluster 74 (138 respondents) titled 'Engineering Systems and Administration';

- cluster 82 (318 respondents) titled 'Civil Engineering and Surveying';

- cluster 68 (123 respondents)titled 'Drafting and Design';

- cluster 34 (188 respondents) titled 'Electrical and Electronic Engineering'.

These four major clusters are quite comprehensive in their coverage of the occupations within the engineering technical workforce, as altogether 96 of the 99 primary clusters were included in one of the four major clusters. The three clusters that were not included may be termed 'outliers'. Outliers merge directly with the whole sample cluster, without merging into one of the major clusters.

One of the outliers, titled 'senior structural analysis and design officers', was positioned between the two major clusters 'civil engineering and surveying' and 'drafting and design', and is shown in Figure 6.4.

The other two outliers, titled 'fluidic and electronic technicians' and 'equipment maintenance technicians', were positioned adjacent to the major cluster 'electrical and electronic engineering', and are shown in Figure 6.5.

<u>Interpretation of the cluster analysis result</u>

All except one of the traditional major engineering disciplines emerged as single distinct major clusters in the cluster analysis.

Civil engineering and surveying emerged as a major cluster, as did electrical and electronic engineering. The interesting feature is that the major field of mechanical engineering did not form a single distinct major occupational cluster, but tended to be included in the two major clusters of:

- engineering systems and administration (27% of members in the mechanical field);

- drafting and design (40% of members in the mechanical field).

The major cluster of Engineering Systems and Administration (cluster 74) includes good numbers of those within mechanical, electrical, civil and electronic engineering. Membership of this cluster seems to be based on the common duties of written and oral communication, staff supervision and general administration, as well as other general engineering duties. Specialised engineering duties are less important in this major cluster. The average age, salary, and contribution of administration and supervision tasks indicates that, in general, these members tend to hold more senior jobs within their organisations than members of the other major clusters.

Cluster membership depends on the relative contribution of each of the 621 tasks in the inventory, so each cluster may be viewed as a group of points in 621-dimensional space. However, the result of the cluster analysis, and in particular the way in which four major clusters emerged, suggests that four broad factors operate, these being:

- the contribution of general tasks and general engineering tasks (including communication, administration and supervision);
- the contribution of drafting and design tasks;
- the contribution of civil engineering and surveying tasks;
- the contribution of electrical and electronic engineering tasks.

This means that if either of the first two factors are dominant for a particular cluster, one of the two major 'non-specialised' major clusters would contain that cluster. For example, if a traditional civil engineering occupational cluster is primarily engaged in drawing, it would appear under the major cluster 'drafting and design'.

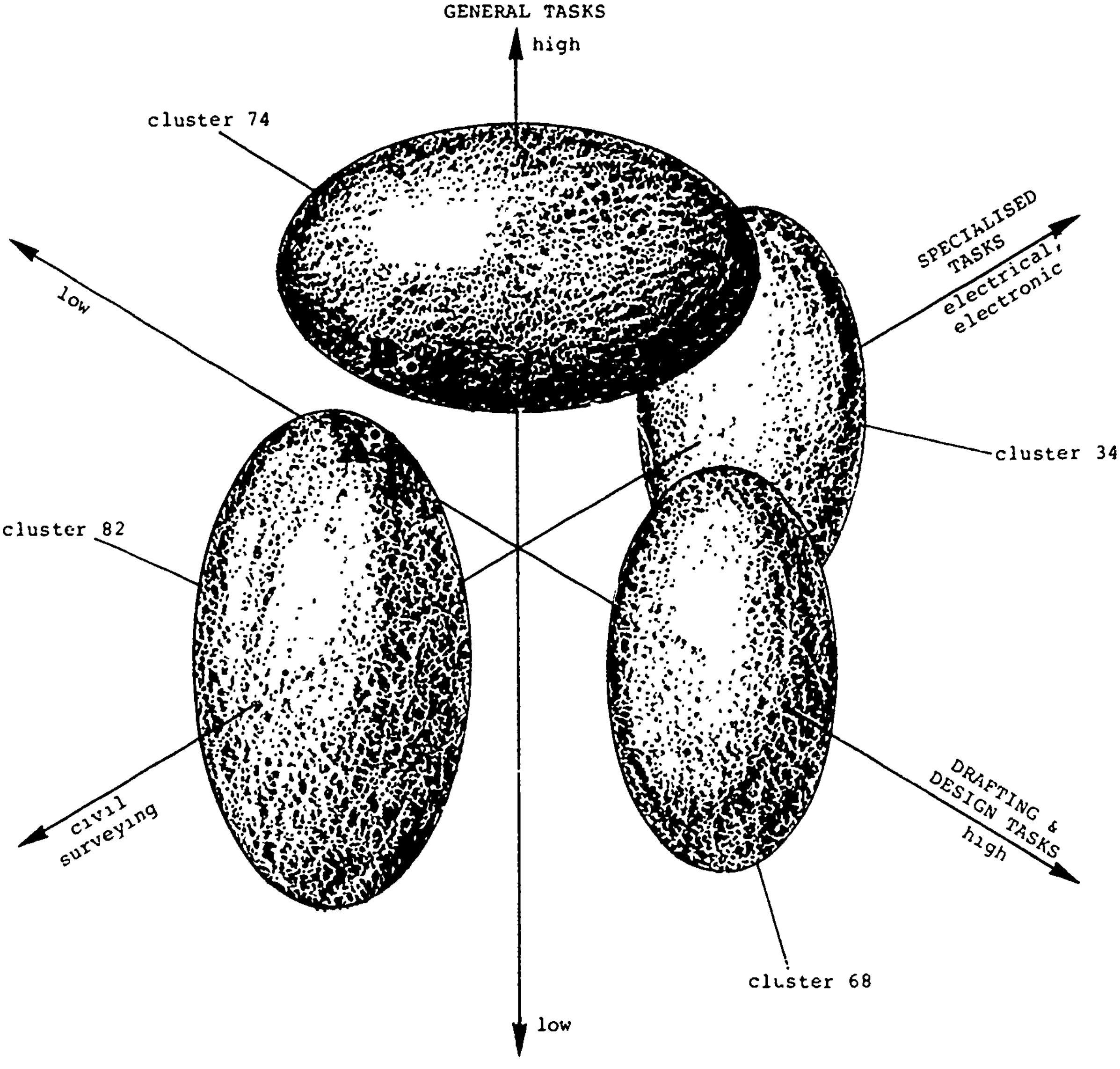
It is postulated that a factor analysis of the 621 task contribution ratings over the whole sample would distinguish four such factors. The project resources did not allow the undertaking of such analysis. This issue could be the subject of further research.

For convenience the above four factors may be condensed to the three factors of:

- general tasks,
- drafting and design tasks,
- specialised engineering tasks.

The four major clusters may then be represented in three-dimensional space, as illustrated (in simplified form) in Figure 6.6.

This Figure illustrates the point that two clusters may be somwhat 'close' in job functions, while still falling within separate major clusters. An example of this would be clusters at points A and B in Figure 6.6.



NOTE: . major cluster 74 = enginering systems & administration
. major cluster 82 = civil engineering & surveying
. major cluster 68 = drafting & design
. major cluster 34 = electrical & electronic engineering

Figure 6.6 The four major clusters in a 3-dimensional space

6.2 BACKGROUND INFORMATION ON THE WHOLE SAMPLE

The purpose of the main survey was to obtain information on the occupational clusters within the engineering technical workforce and in particular, information on the job junctions of each cluster. Nevertheless it will be useful to examine the sample of respondents as a whole, in order to allow some comparisons with past and future studies and to provide some indication of the general characteristics of the engineering technical workforce in Australia.

Some caution should be exercised in applying the whole sample information to the engineering technical workforce population. As discussed in Chapter 4, the sampling procedure aimed to obtain a large and comprehensive sample, and the net sample of 1230 respondents may not give an accurate indication of population characteristics. Nevertheless the sample provided some useful information on the broad characteristics of the engineering technical workforce.

The whole sample consisted of 1230 respondents. As reported in Chapter 4, 1821 survey booklets were sent out and 1380 booklets were returned. Of the returns, 1230 were usable and 150 were not usable for various reasons (e.g. 58 answered "no" to question 1, and 55 were returned after the deadline).

Part A of the survey booklet sought background information on the respondent and his/her workplace, and consisted of 13 questions. A copy of the survey booklet is given in Appendix F. The first nine questions were concerned with the respondent and his/her job.

Question 1 asked the respondent: 'Are you presently employed in any engineering occupation with functions somewhere between tradesperson and professional engineer or surveyor?' This question acted as a final filter to help insure that only engineering technical workers were included in the sample. A total of 58 respondents answered 'no' to this question and these were excluded from further analysis.

Question 2 asked the respondent to indicate his/her age. The age of respondents ranged from 16 to 63 years, the average being 33 years. Figure 6.7 shows the age distribution of the whole sample. The sample average age of 33 years is a little lower than the 36 year average of the sample of engineering technical workers in the Kinhill Stearns study (see Section 3.4).

In question 3 respondents were asked to indicate their sex. The responses showed that the proportion of females in the sample was very low, there being 32 females representing 2.6% of the sample. This proportion is similar to that found in other studies, such as the Kinhill Stearns study reported in Section 3.4.

In question 4 respondents were asked to indicate the job title closest to their own job title by selecting from a list of 12 job titles. The 12 titles did not include names of engineering fields or branches. For example, it was expected that a person with the title of 'electronic technician' would choose the title 'technician' from the list of 12 titles.

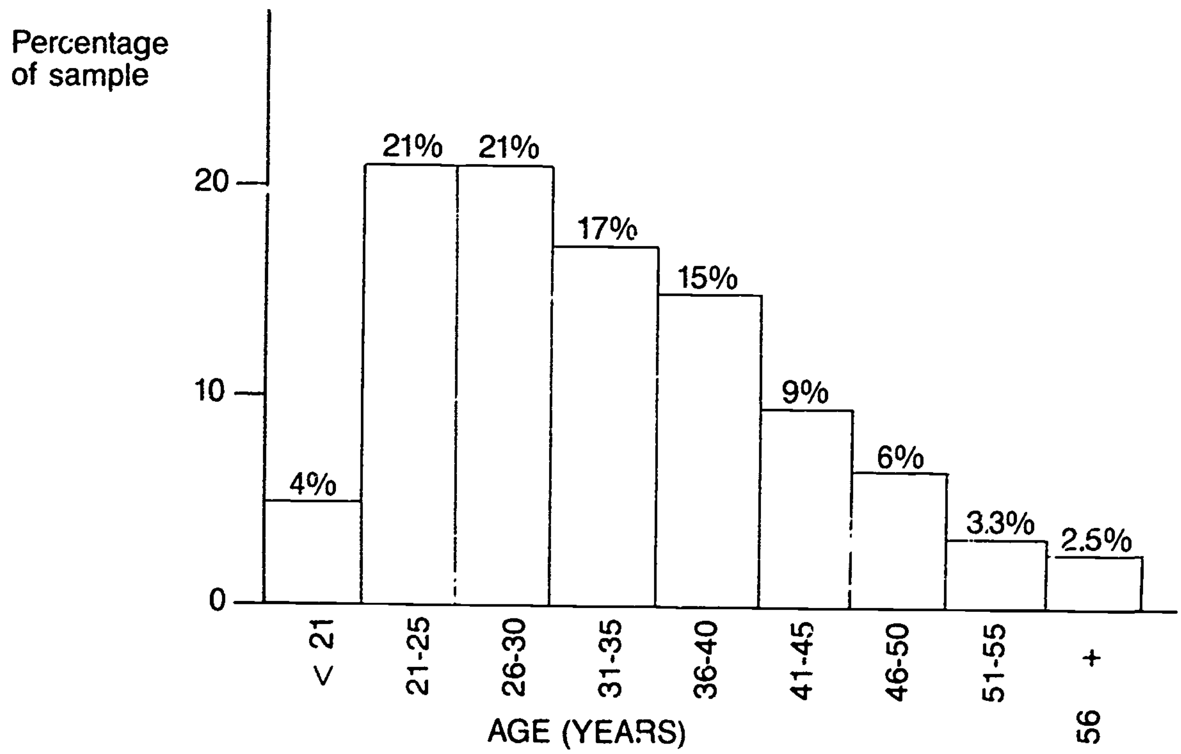


Figure 6.7 Age distribution of the sample

Table C-1 in Appendix C gives the frequency cross-tabulation of job titles by fields of engineering. The job title of 'technical officer' was the most common overall, applying to 334 respondents or 27% of the sample. The table indicates significant variation in the distribution of job titles among the various fields of engineering. A marked feature is the high use (25% of those in electronic engineering) of the term 'technician' in electronic engineering.

Question 5 sought information on the respondent's salary at the time the survey was conducted (April 1985). The salary distribution of the sample is given in Figure 6.8. From this distribution the average salary of the sample was estimated at $23,000.

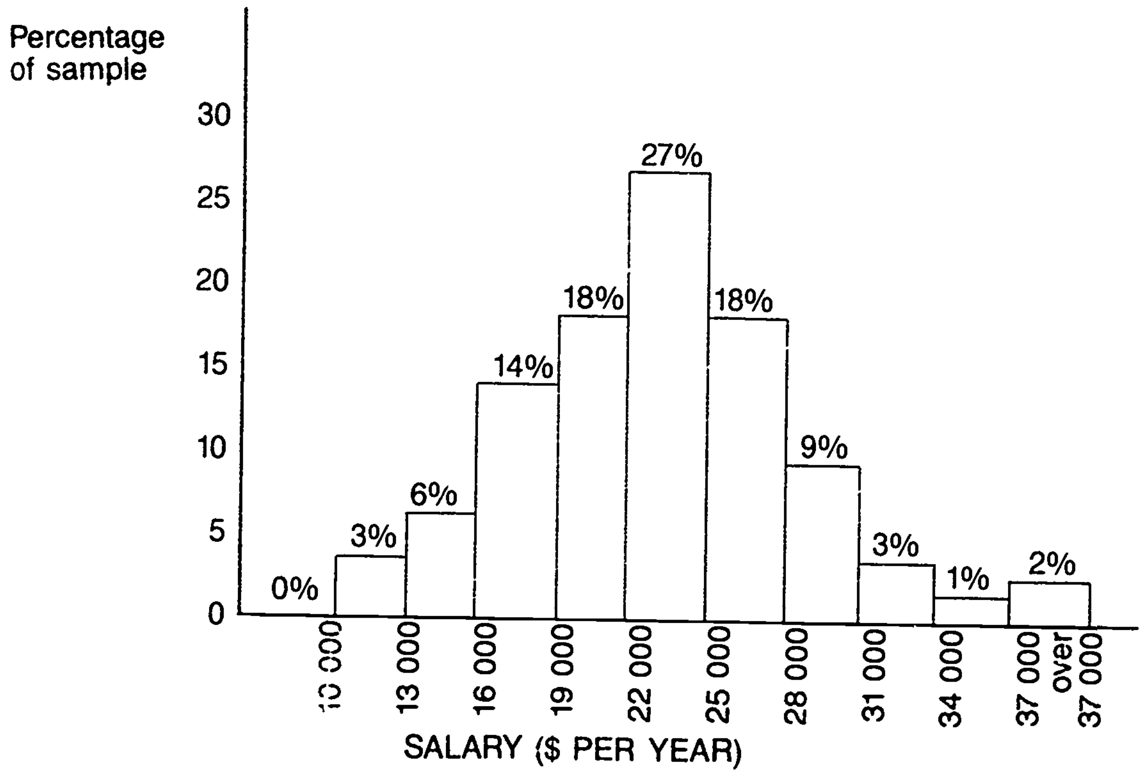


Figure 6.8 Salary distribution of the sample, as at April 1985

Questions 6 and 7 sought information on the length of time the respondent had been in his/her present position and the length of time employed in engineering occupations. Over the whole sample the average length of time in the 'present position' was found to be 5.5 years and the average length of time in engineering occupations was found to be 14.5 years. The distributions of both of these variables are given in Figures 6.9 and 6.10.

Question 8 asked respondents to nominate the field of engineering in which they were mainly engaged. Table B-1 in Appendix B gives the overall distribution of nominated fields and the frequency cross-tabulation of job titles by nominated fields of engineering. This table indicates that civil engineering was nominated most frequently as the main field of respondents, being nominated by 22% of the sample. The next most frequently nominated was mechanical engineering (17%), followed by electronic engineering (15%) and electrical engineering (13%).

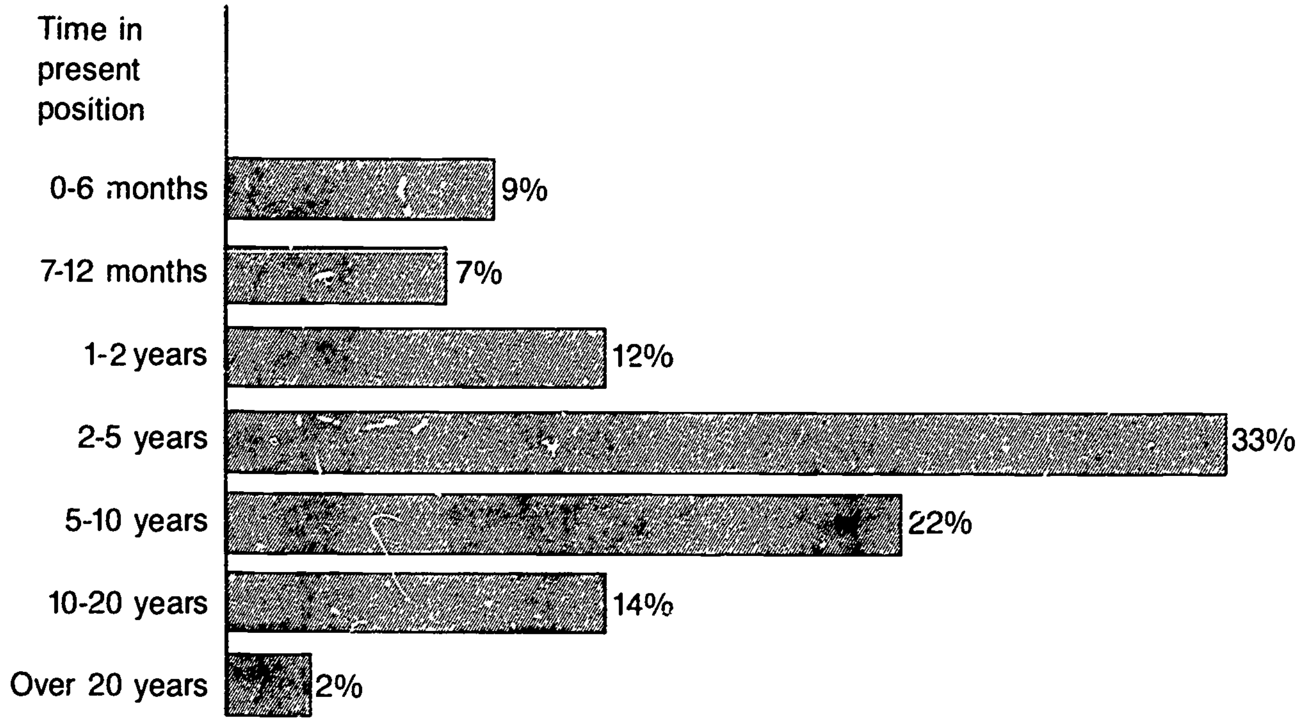


Figure 6.9 Distribution of time in present position for the whole sample (n = 1230)

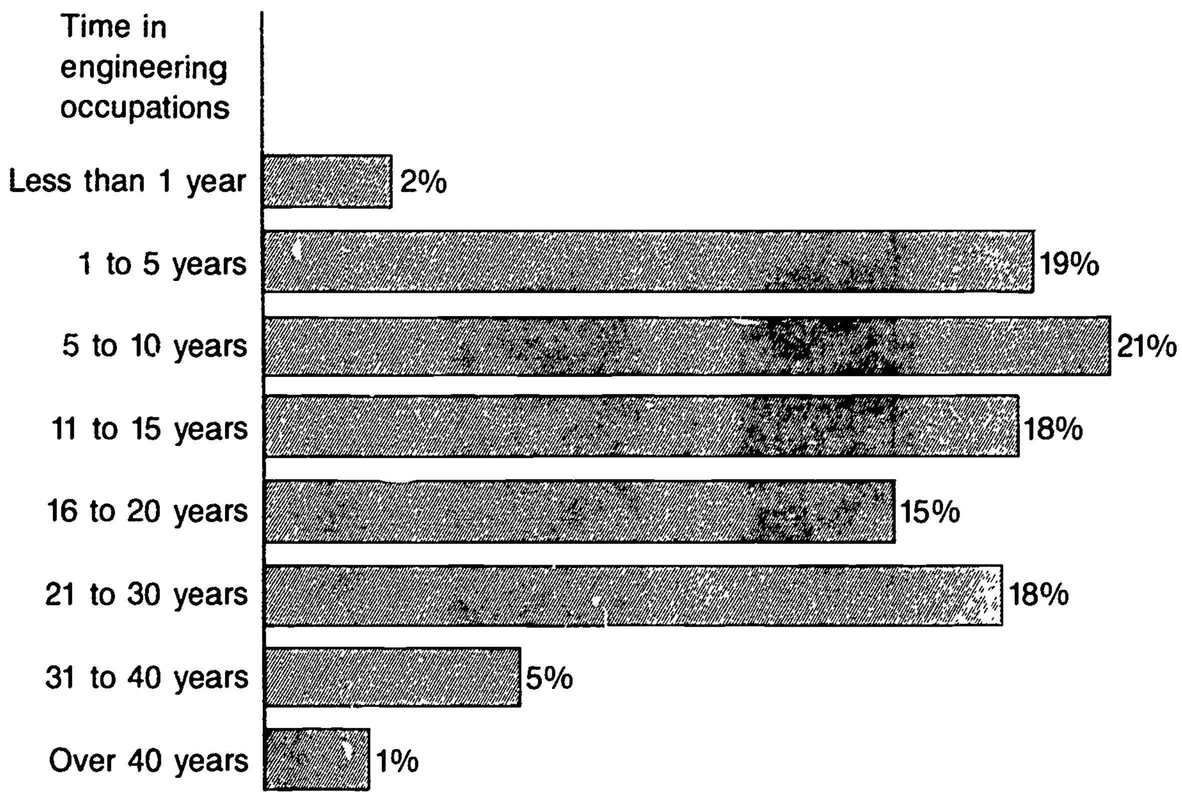


Figure 5.10 Distribution of time in engineering occupations for the whole sample (n = 1230)

The very low representation of work study/methods engineering was unexpected. Only 2 of the 1230 respondents nominated this field as their main field of engineering activity. However, 153 of the 1230 respondents performed one or more work study tasks (duty 'AS' in the questionnaire), with 114 respondents determining workplace layout and 80 respondents performing work measurement. It is suspected that many of the 153 respondents who performed one or more work study tasks nominated production engineering or mechanical engineering as their main field.

Question 9 sought information on the respondents' engineering educational attainments. Respondents could indicate more than one educational attainment and the last year of study for each.

A large number of respondents indicated more than one engineering educational attainment. Of the 1230 respondents, 55 gave no response, 500 indicated one educational attainment, 354 indicated two educational attainments, and 160 indicated three or more educational attainments.

The responses to question 9 on engineering educational attainments were analysed in three ways based on:

- the distribution of <u>all</u> engineering educational attainments;
- the distribution of <u>most recent</u> engineering educational attainments;
- the distribution of <u>highest</u> engineering educational attainments.

Table B-2 in Appendix B gives the distribution of <u>all</u> engineering educational attainments of the whole sample. Completion of a certificate course at a technical college was the most common attainment, with 469 respondents indicating this attainment. The second most common attainment was completion of a trade technical or technician course at a technical college, with 322 respondents indicating this attainment.

Table B-3 in Appendix B gives the distribution of the <u>most recent</u> engineering educational attainments of the whole sample. The most common attainment by far is completion of a certificate course at a technical college (340 respondents). When this distribution is compared with that given in Table B-2, the most notable change is in the number completing a trade technical or technician course. It is clear that a large number of

respondents had completed a trade course and subsequently undertaken further studies, as 322 respondents had completed a trade course (Table B-2) but of these, only 71 (Table B-3) had this as their most recent attainment.

In this study the most pertinent educational variable is that of highest engineering educational attainment. Each respondent's indicated attainments were recorded on a predetermined hierarchical scale of level of education, as given in Table B-4 in Appendix B. When more than one attainment was indicated, only the 'highest' on the scale was recorded. It is important to note that for the purpose of this study, engineering certificate and associate diploma courses were regarded as equivalent in level and thus their frequencies combined. The resulting frequencies of highest engineering engineering educational attainments are given in Table 6.1.

Easily the most common highest attainment was a completed certificate or associate diploma course, which was indicated by 44% of the sample. Table 6.1 also confirms, when compared with Table B-2, a significant number of respondents upgrading their educational qualifications. In particular, a large number of respondents (288) had completed a trade course but had started or completed a higher course.

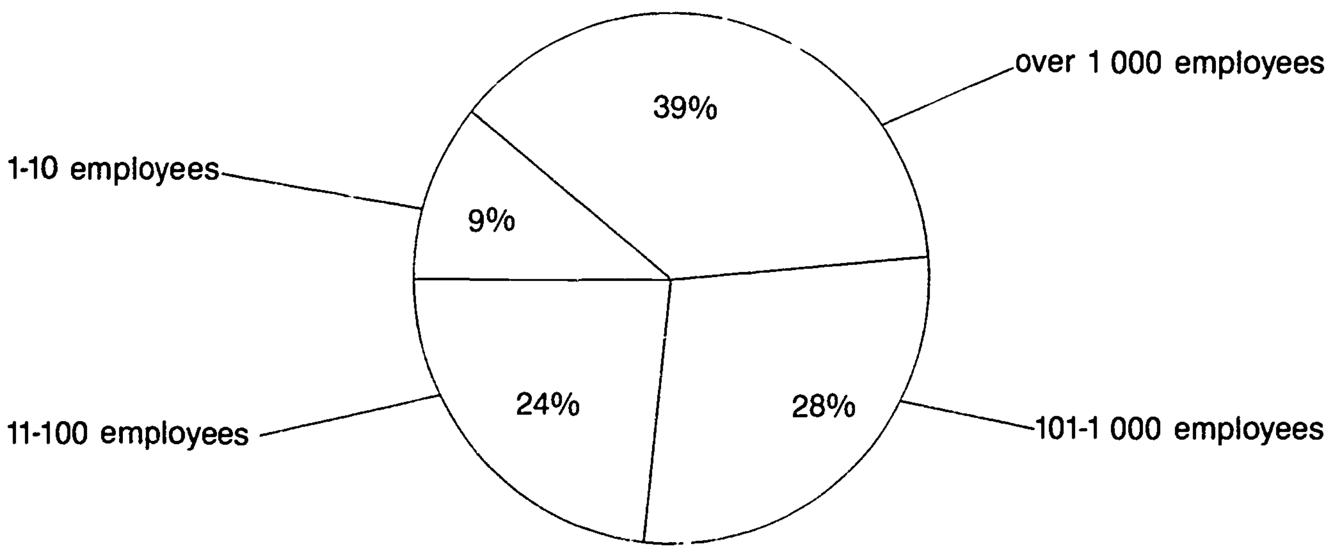
It was also of interest in this study to note the percentage of respondents who had completed a certificate course or higher, as this is the qualification that is generally regarded as standard for the engineering associate level of the workforce (see Section 3.3). For each cluster and the whole sample, this percentage was computed by adding the percentages of each category at or higher than 'completed certificate' in the hierarchy in Table B-4. In some cases this could lead to a difficulty, as some respondents may only have partly completed a degree or diploma, which is arguably not as high as a completed certificate or higher. In practice however this was not a large problem, because only a small percentage (2%) had no qualifications above completed certificate other than a part degree or diploma.

It was found that for the whole sample, 65.6% had a certificate or higher attainments (which may be termed associate level qualifications) and 34.5% had part certificate or lower attainments (which may be termed technician level qualifications).

TABLE 6.1 FREQUENCY CROSS-TABULATION OF HIGHEST ENGINEERING EDUCATIONAL ATTAINMENT BY TYPE OF COURSE AND TYPE OF ATTAINMENT

TYPE OF COURSE	TYPE OF ATTAINMENT: CURRENTLY IN PROGRESS	COMMENCED BUT NOT CONTINUED	COMPLETED	TOTAL
Other course	1 (0%)	1 (0%)	34 (3%)	36 (3%)
Trade technical or technician	6 (1%)	7 (1%)	56 (5%)	69 (6%)
Post-trade course	7 (1%)	11 (1%)	36 (3%)	54 (5%)
Certificate or associate diploma course	179 (15%)	67 (6%)	517 (44%)	763 (65%)
Degree or diploma course	39 (3%)	90 (8%)	57 (5%)	186 (16%)
TOTAL:	238 (20%)	189 (16%)	748 (64%)	1175 (100%)

NOTES
1. All percentages indicate the percentage of the total number of non-blank responses.
2. Of the sample of 1230 respondents there were 55 blank and 1175 non-blank responses to question 9 on engineering educational attainments.



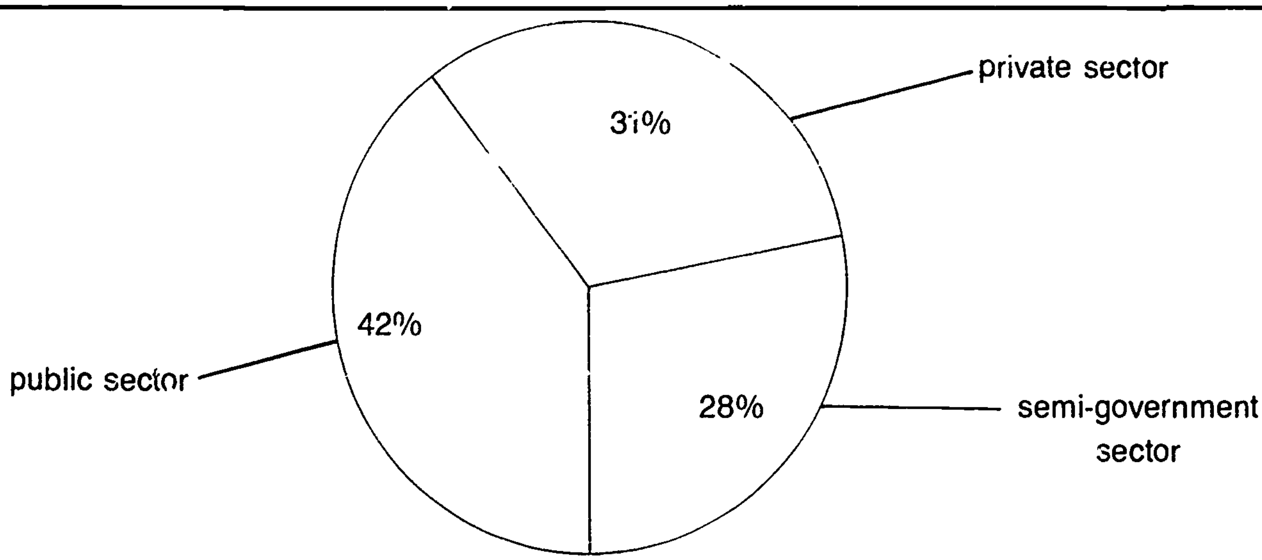
NOTE: For the sample, there were 9 blank and 1 221 non-blank responses to Question 10.

Figure 6.11 Distribution of the sample of engineering technical workers by size of organisation (n = 1221)

Question 10 asked respondents to indicate the size of their current organisation in terms of the number of employees. The distribution of size of organisation for the whole sample is given in Figure 6.11. This distribution confirms the findings of other studies suggesting that the major employment category for the engineering technical workforce is the madium to large organisations (see Section 3.4). In this study, 68% of the sample were employed in firms having over 100 employees.

Question 11 asked respondents to indicate in which sector (i.e. private, semi-government or public sector) they were employed. The distribution of the sample among the three sectors is given in Figure 6.12. The distribution indicates that the public sector (federal, State and local government) and the semi-government sector (e.g. public utility organisations) are the major employers of engineering technical workers, accounting for 69% of this sample. This study suggests that the private sector employs a relatively low percentage of engineering technical workers, represented by 31% of the sample, and this result is similar to that obtained in a previous study in Western Australia (see Cochrane, 1977, and Section 3.4).

Question 12 sought information on the location of the respondent's current place of work. The distribution of the sample among the eight States and Territories and the four types of area (ranging from capital city to country) are given in Figure 6.13.



NOTE: For the sample, there were 18 blank and 1 212 non-blank responses to Question 11.

Figure 6.12 Distribution of the sample of engineering technical workers by sector (n = 1221)

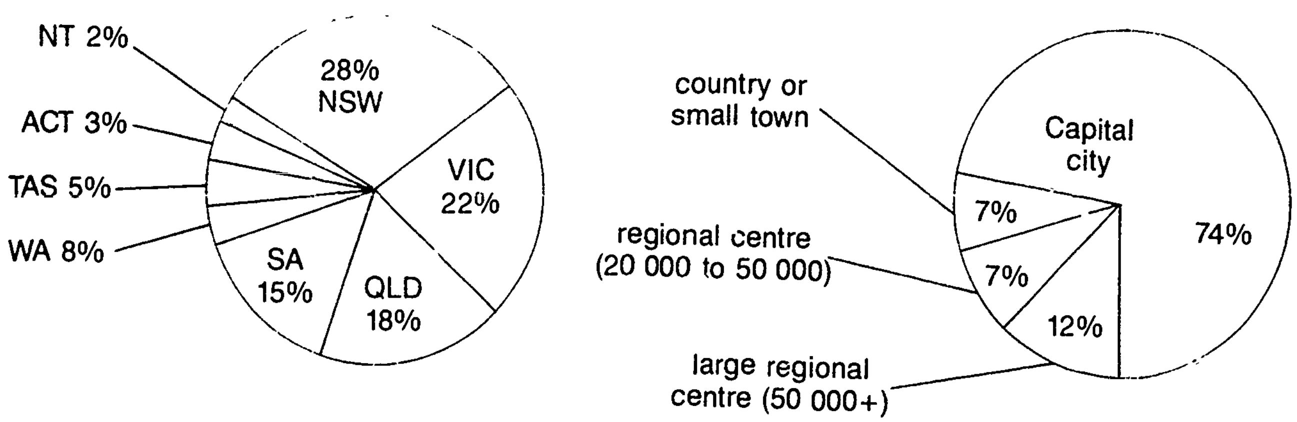


Figure 6.13 Distribution of the sample of engineering technical workers among the States and Territories and type of area

The distribution of the sample among the States and Territories differs a little from the estimate of the technical workforce population distribution given in Table A-1 (Appendix A). The sample percentages of the large States, New South Wales and Victoria, are lower than the population percentages, reflecting a lower response rate in these two States. Percentages for Queensland, South Australia and Tasmania are higher than the population percentages of Table A-1, reflecting a higher response rate in these States. Western Australia, the Northern Territory and the Australian Capital Territory are about the same as the population estimates, the differences being not statistically significant.

The distribution of the sample among the four types of area reflects general population characteristics. As expected, the capital cities of Australia provide the main employment locations for the engineering technical workforce, with 74% of the sample indicating a capital city location.

Question 13 was the final question in Section A of the questionnaire, and this sought information on the main type of activity of the respondent's employing organisation. The industry categories used in the questionnaire correspond with those used in the Australian Census.

Table B-5 in Appendix B gives the distribution of the sample crosstabulated by industry activity and the respondent's field of engineering. Over the whole sample, the two industry categories nominated the most were 'D. Electricity gas and water' and ' E. Construction', but the distribution varies

considerably among the various fields of engineering. It is interesting to note the difference in the distributions of those in electronic engineering compared with those in electrical engineering. The electronic engineering respondents are concentrated in 'communication' and 'defence' (30% and 20% of electronic engineering respondents respectively) while the electrical engineering respondents and concentrated in 'electricity, gas and water' (41% of electrical engineering respondents).

6.3 JOB FUNCTIONS OF THE WHOLE SAMPLE

In this section an overview of the range of job functions and their relative contribution for the whole sample is presented.

The sample of 1230 respondents represents a very broad occupational group-the engineering technical workforce. For curriculum development purposes, narrower occupational groups are of more interest, though some general characteristics of the engineering technical workforce may provide important insights. Later sections of this chapter deal with job functions in much greater detail, when the narrower occupational groups are discussed.

Section B of the survey booklet consisted of an inventory of 621 tasks. These tasks were chosen to represent the full range of tasks undertaken by the engineering technical workforce, but respondents were invited to write in additional tasks not included in the inventory. As explained in Chapter 4, respondents were asked to rate the contribution of each task to their job.

The 621 tasks were grouped into 61 duties. These 61 duties were further grouped into four broad job function areas as follows:

- general (18 duties, 167 tasks);
- mechanical/manufacturing (15 duties, 149 tasks);
- electrical/electronic (15 duties, 199 tasks);
- civil engineering/surveying (13 duties, 106 tasks).

This grouping into four areas was not shown on the survey booklet. Classification of the duties into the four areas was undertaken a priori to assist in the analysis and interpretation of job functions.

The four areas and 61 duties are listed in Table 6.2, and the 621 tasks are listed in Appendix C.

Figure 6.14 shows the relative contribution of each of the four job function areas to the work of the engineering technical workforce sample. The distribution confirms the relatively high contribution of general job functions (such as communication, drawing, administration and supervision) over more specialised engineering job functions.

There are two main reasons for the high contribution of general job functions. Firstly, this area is significant in all of the major clusters (see Section 6.5). Secondly, many duties in this area are common across a large number of clusters (see Section 7.2)

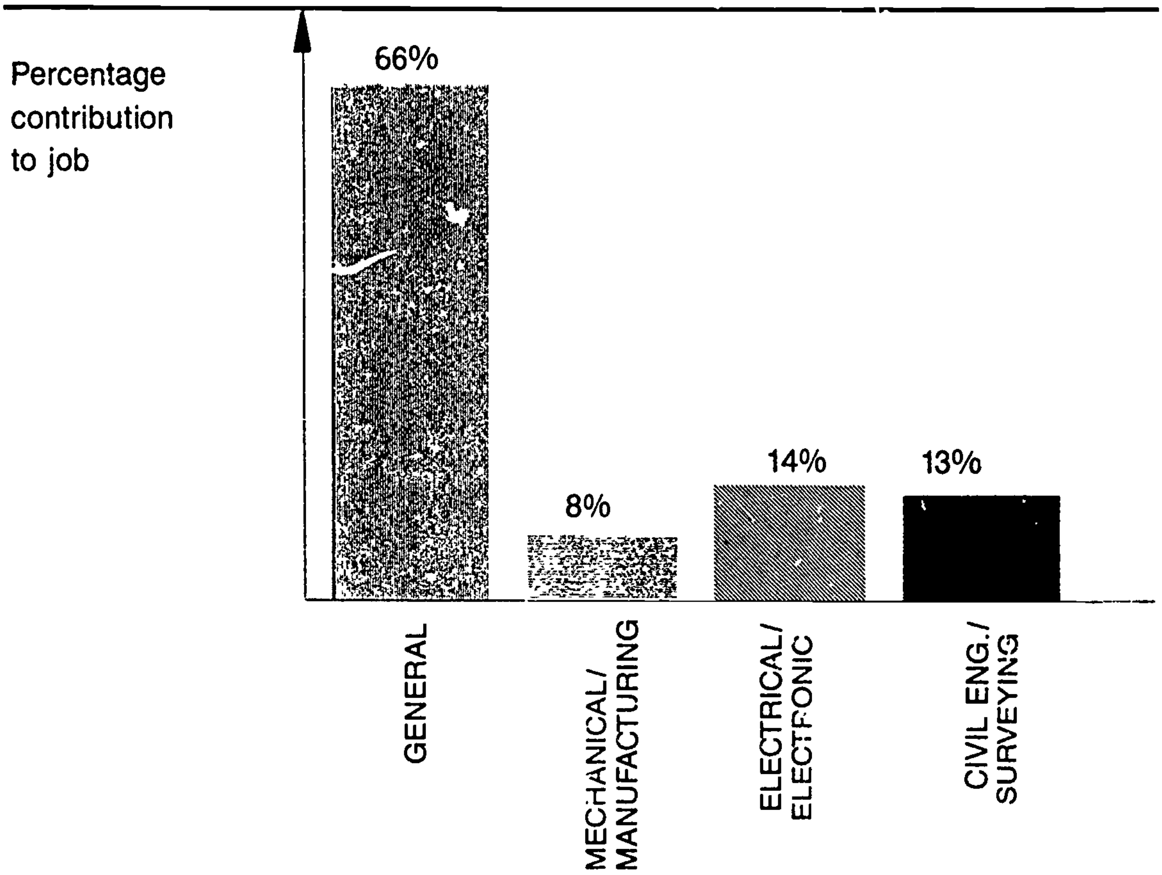


Figure 6.14 Relative contribution of each of the four broad job junction areas to the work of the whole sample

Table 6.2 gives the <u>duty profile</u> of the whole sample, showing the percentage of the sample performing each duty and the relative contribution of each of the 61 duties. In calculating the percentage of the sample performing each duty, a respondent was counted as performing the duty if the respondent indicated that he/she performed one or more tasks within that duty. The

TABLE 6.2 DUTY PROFILE OF THE WHOLE SAMPLE (n = 1230)

AREA	DUTY	PERCENTAGE OF SAMPLE PERFORMING DUTY	PERCENT CONTRIBUTION TO JOB OVER WHOLE SAMPLE
GENERAL	A. Project planning and management	53	2.6
	B. General administration	83	7.6
	C. Written communication	93	9.4
	D. Oral communication	96	9.2
	E. Finance and estimating	57	2.9
	F. Purchasing	57	2.4
	G. Staff development	53	2.4
	H. Staff supervision	73	3.3
	J. Quality assurance/quality control	25	1.1
	K. Quality testing and measuring	37	2.2
	M. Maintenance	44	3.5
	N. Safety	35	1.0
	P. Site inspection and investigation	50	2.4
	Q. Data collection and analysis	46	2.1
	R. Use of calculators and computers	92	6.1
	W. Engineering drawing and graphics	72	4.5
	X. Design drafting	48	2.7
	BN. Still and movie photography	36	.5
MECHANICAL/MANUFACTURING	L. Materials testing	17	.6
	AE. Earth moving and mining	8	.2
	AF. Motorised transport systems	9	.4
	AG. Process plant engineering	11	.4
	AH. Metal fabrication, turning and casting	15	.8
	AJ. Wood, paper, plastics and packaging	5	.1
	AK. Building services	21	.7
	AL. Advisory and specialist services	28	.9
	AM. Construction	21	1.0
	AN. Biotechnology and ergonomics	4	.1
	AP. Tooling and equipment	20	1.2
	AQ. Materials handling	10	.2
	AR. Production engineering	7	.2
	AS. Work study	12	.3
	AT. Fluid power	11	.4
ELECTRICAL/ELECTRONIC	S. Computer and digital control equip.	18	.7
	T. Computing systems	15	.4
	U. Digital and computing hardware	20	2.1
	V. Computing software	8	.3
	AA. Electronic fabrication	18	.8
	AB. Power generation, energy transfer	20	.9
	AC. Electrical power generation, transmiss	16	1.3
	AD. Automatic control system	19	1.2
	AU. Electrical instruments and sensors	26	1.3
	AV. Power electronic devices	19	.8
	AW. Electrical protection devices	20	1.1
	AX. Power transformers, circuit breakers	12	.6
	AY. Electrical drives	13	.5
	AZ. Electronic communication	13	.8
	BA. Other electronic devices	13	.8
CIVIL ENGINEERING/ SURVEYING	Y. Engineering survey drafting	33	2.2
	Z. Cadastral survey drafting	10	.4
	BB. Engineering surveying	13	2.6
	BC. Cadastral surveying	12	.3
	BD. Hydrographic surveying and drawing	6	.1
	BE. Survey computations	33	2.1
	BF. Civil design and computations	28	1.5
	BG. Structural design and computations	18	.8
	BH. Hydrology and hydraulics	18	.8
	BJ. Town planning	7	.2
	BK. Cartography	15	.6
	BL. Air photo and map interpretation	20	1.0
	BM. Survey investigation and searching	14	.5
	TOTAL PERCENTAGE CONTRIBUTION		100.0

percentage contribution of each duty was calculated by summing the average percentage contributions of each task within the duty. The average percentage contributions of all tasks over the whole sample are given in Appendix C.

The top five duties, in terms of the percentage contributon of each, duty were:

- written communication (9.4%);
- oral communication (9.2%);
- general administration (7.6%);
- the use of calculators and computers (6.1%);
- engineering drawing and graphics (4.5%).

For the whole sample the top duty was *written communication* and it was performed by 1139 respondents (93%). For those who performed this duty, the average percentage contribution of the duty to their job was 10.1%. Over the whole sample, the average percentage contribution of this duty was 9.4%.

For the whole sample, the bottom duty in terms of overall contribution was *biotechnology and ergonomics*, and it was performed by 44 respondents (4%). For those who performed this duty, the average percentage contribution of the duty to their job was 2.6%. Over the whole sample, the average percentage contribution of this duty was 0.09%.

Appendix C gives the task level job description of the whole sample. An explanation of the meaning of values in each colunm is given in Section 3.5. The two values of most interest here are:

- column 1, giving the percentage of the sample that perform each task;

- column 3, giving the percentage contribution to job over the whole sample (over the whole task inventory, column 3 sums to 100%).

Appendix C contains the following results worthy of particular note:

- The average number of tasks performed by respondents in the sample was 79 tasks from the inventory of 621 tasks.

- The task making the highest percentage contribution over the whole sample was 'D3. Exchange information with other

people within your organisation.' (89% of respondents indicated that they perform this task, and its contribution over the whole sample was 2.1%);

- Only two of the 621 tasks were not performed by any of he respondents, and this provides support for the face validity of the task inventory.

- 20% of respondents wrote in one or more additional tasks when given the opportunity at the end of the task inventory. Over the sample of 1230 respondents, 982 (80%) wrote in no extra tasks, 109 (9%) wrote in one extra task, 60 (5%) wrote in two extra tasks, 36 (3%) wrote in three extra tasks, and 43 (3%) wrote in four or more extra tasks. For those who wrote in one or more extra tasks, the average contribution to their job of these tasks was 6.2%. For 13 respondents, the contribution of these write-in tasks was over 20%. It is interesting to note that of these 13, all except two were members of outlying clusters, that is, clusters outside the four major clusters. However the contribution of the write-in tasks over the whole sample was low, being 1.2% in total. These statistics tend to provide support for the validity of the task inventory developed for this survey, indicating that the task inventory quite adequately covered the work of the engineering technical workforce.

6.4 BACKGROUND INFORMATION ON THE MAJOR CLUSTERS

Information on the important background variables for each of the four major clusters is given in Table 6.3. On all of the background variables shown in this table, variation among the major clusters is statistically significant (at the .05 level of significance or better). Some of the interesting results are:

- Engineering systems and administration is composed of members having the highest average age (37 years) and highest average salary ($25,100 in 1985).

- Drafting and design has the highest percentage of females (4.9%) whereas electrical and electronic engineering has the lowest percentage of females (0.5%).

- Civil engineering and surveying has the highest overall level of education (81% having completed an engineering certificate or higher) while electrical and electronic

TABLE 6.3 BACKGROUND INFORMATION AND JOB FUNCTIONS OF THE FOUR MAJOR CLUSTERS

CLUSTER NO.	74	82	68	34
TITLE OF CLUSTER	Engineering systems and administration	Civil engineering and surveying	Drafting and design	Electrical and electronic engineering
Number of respondents	438	318	123	188
Average age (years)	37	33	29	30
Female percentage	1.6%	4.2%	4.9%	0.5%
Average salary ($, 1985)	$25,100	$22,700	$20,000	$22,300
Job title (modes over 10%)	technical off. 34% supervisor 18% other 14% design draftsm. 10%	design draftsm. 24% technical off. 21% eng. assis. 18%	design draftsm. 43% detail draftsm. 23% technical off. 10%	technical off. 41% technician 23% tradesm. 10%
Field of engineering (modes over 10%)	mechanical 27% electrical 22% other 12% civil eng. 10%	civil eng. 62% surveying 20%	mechanical 40% structural 21% electrical 11%	electronic 64% electrical 17%
Education *	68%	81%	70%	50%
Private sector percentage	29%	20%	56%	32%
State (modes over 10%)	NSW 29% SA 19% VIC 18% QLD 16%	NSW 27% QLD 26% VIC 21%	VIC 34% NSW 29% SA 14% QLD 13%	NSW 24% VIC 23% SA 19% QLD 13% ACT 11%
Industry categories (modes over 10%)	elect,gas,water 16% construction 18% non-class. 13%	construction 31% publ. admin. 11% gen.consult. 16% non-class. 21%	manufact. 23% elect,gas,water 18% construction 11% gen.consult. 16%	elect,gas,water 23% wholesale, retail 11% communication 16% defence 16% non-class. 13%
Average number of tasks	94	94	41	90
Level index *	65	64	57	60
Administration duty - % contribution	10.3	6.7	8.2	4.4
Supervision duty & tasks - % contrib.	11.7	8.1	5.8	5.4
Top ten duties	written commun. oral commun. general admin. finance & estimating calc. & computers proj. planning,mangt. staff supervision purchasing staff development eng.drawing,graphics	written commun. eng. surveying calc. & computers survey computations oral commun. general admin. eng.survey drafting eng.drawing,graphics site inspect./invest. civil design,comput.	eng. drawing & graphic written commun. oral commun. design drafting general admin. calc. & computers staff supervision eng.survey drafting struct.design,comput. metal fab.turn.,cast.	digital & comput.h/wre maintenance oral commun. written commun. calc. & computers quality testing & meas. general admin. elec.instr. & sensors power electronic devices other electronic devices

* NOTE.
1. Education indicates the percentage of members of the cluster who have completed a certificate course in engineering or higher.
2. Level index indicates the average level of tasks peformed by members of the cluster. The minimum 0 indicates all tasks are performed by lower middle level technical workers or tradespeople. The maximum of 100 indicates that all tasks are performed by upper middle level technical workers or professional engineers. The actual range for all clusters is 47 to 72.

engineering has the lowest overall level of education (50% having completed an engineering certificate or higher). The full distribution of highest educational qualifications for each of the four major clusters is given in Table C-6 in Appendix C.

6.5 JOB FUNCTIONS OF THE MAJOR CLUSTERS

There are large differences in the job junctions of the four major clusters, and this is apparent even at the broad area level. Figure 6.15 shows the relative contribution of each of the four main areas to the work of each of the major clusters.

The most notable feature is the high contribution of duties in the <u>general</u> area for all four major clusters. The general area contributes 50% or more for each major cluster. For the drafting and design cluster, it is useful to separate the two drafting and design duties (duty W. and duty X.) from the general area because in this case they are more appropriately described as specialist duties. Together, these two duties contribute 28% to the work of the drafting and design cluster, leaving a contribution of 50% in the general area. Thus, a useful approximation is that duties in the general area (such as communication, administration and supervision) contribute to about half of the work of the major clusters except engineering systems and administration, which has a contribution of over three-quarters (77%) in the general area. The remaining proportions are filled by specialised engineering duties.

Figure 6.16 gives the job descriptions at duty level of each major cluster, and Table 6.3 gives the top ten duties for each major cluster.

As expected, duties in the general area usually provide moderate or higher contributions to the work of at least two (but usually three or four) of the four major clusters. In addition, four duties appear in the top ten of all major clusters, as follows:

- B. general administration
- C written communication
- D. oral communication
- R. use of calculators and computers.

The subject of common duties is discussed further in Section 7.1.

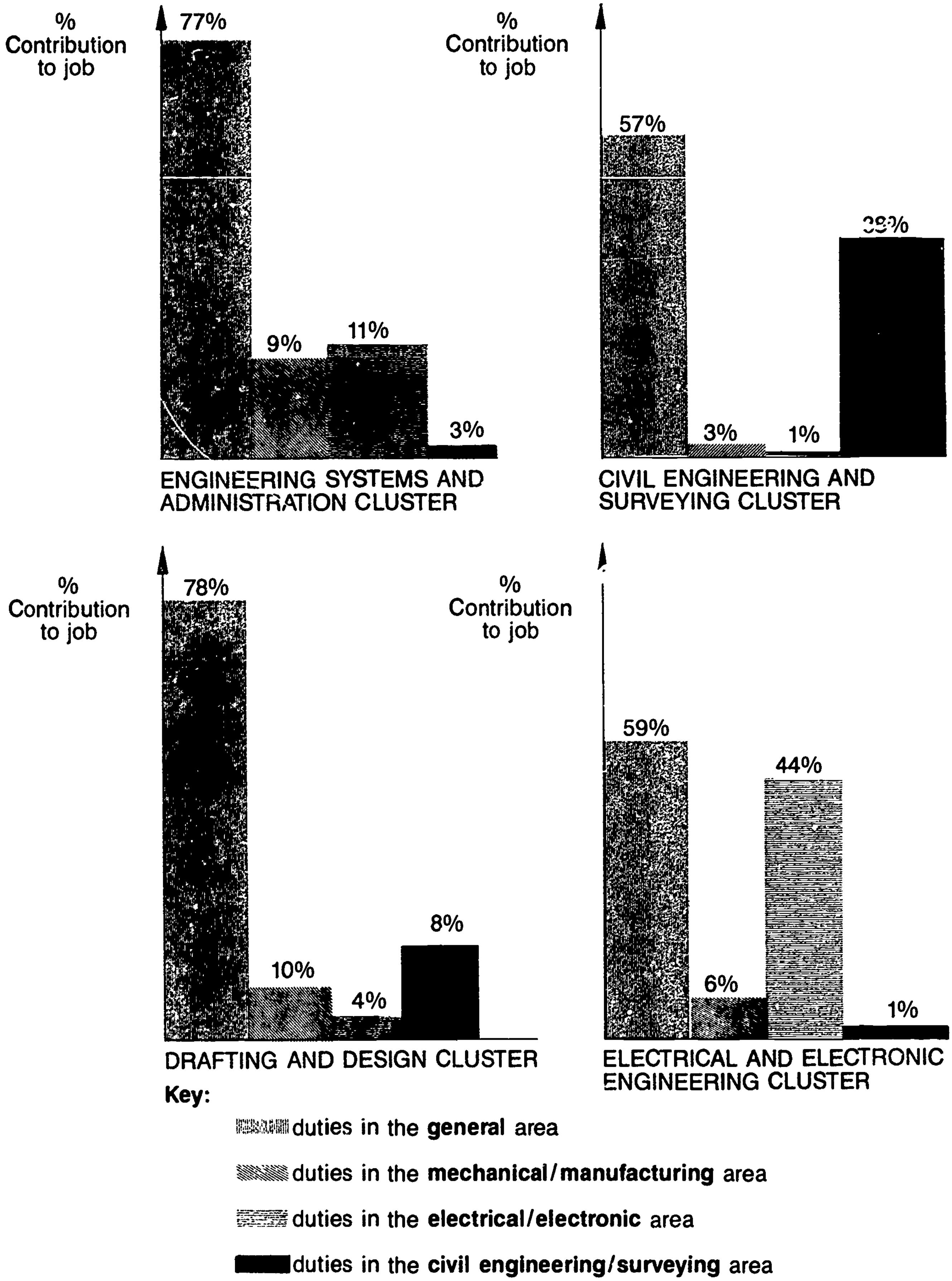
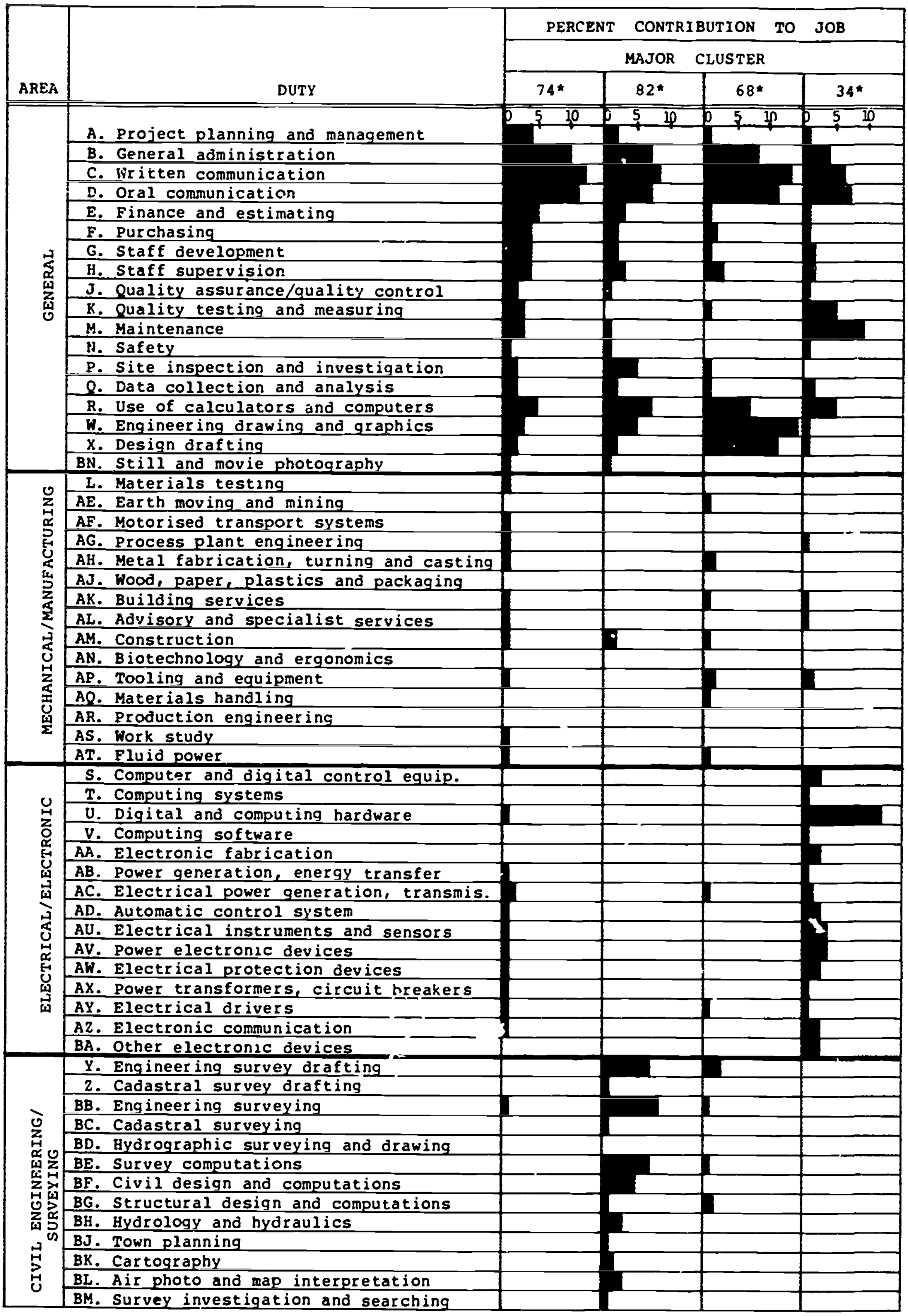


Figure 6.15 Job descriptions at area level for the four major clusters



*NOTE: Cluster 74 = Engineering systems and administration
Cluster 82 = Civil engineering and surveying
Cluster 68 = Drafting and design
Cluster 34 = Electrical and electronic engineering

Figure 6.16 Job descriptions at duty level for the four major clusters

Appendix D gives the job descriptions at duty level of each major cluster. To save space, only the first two pages, giving the top 60 tasks in terms of percentage contribution to job, are given for each cluster. The headings for columns 1, 2 and 3 give the cluster number. Section 3.5 in Chapter 5 provides an explanation of the values in each column.

For the major cluster engineering systems and administration, the top task in terms of overall percentage contribution to job was:

'D3. Exchange information with other people within your organisation.'

It was performed by 98% of the cluster and contributed 1.9% to the work of the cluster overall.

Scanning the first words (all of which are verbs) of each task in the top 60 provides an overview of the type of work involved. The following verbs occur repeatedly:

- exchange;
- read;
- write;
- prepare;
- supervise.

For the major cluster civil engineering and surveying, the top task was:

'R1. Use calculators.'

It was performed by 97% of the cluster and contributed 1.9% to the work of the cluster overall.

For this cluster the following verbs appear repeatedly in the top 60 tasks:

- calculate
- perform
- produce
- prepare
- inspect.

For the major cluster drafting and design, the top task was:

W4. Produce drawings using conventional equipment.

It was performed by 93% of the cluster and contributed 4.8% to the work of the cluster overall.

For this cluster the following verbs appear repeatedly in the top 60 tasks:

- prepare
- produce
- draw
- design.

For the major cluster electrical and electronic engineering, the top task was:

D3. Exchange information with other people within your organisation.

It was performed by 92% of the cluster and contributed 1.7% to the work of the cluster overall.

For this cluster the following verbs appear repeatedly in the top 60 tasks:

- monitor
- test
- repair
- diagnose
- fault-find.

6.6 CLUSTERS WITHIN ENGINEERING SYSTEMS AND ADMINISTRATION

There were 44 primary and 21 intermediate clusters found within engineering systems and administration. Figure 6.2 shows the titles of these clusters and the linkages between the primary and intermediate clusters.

As mentioned in Section 6.1, it appears that the engineering systems and administration clusters were grouped in this one major cluster because of their emphasis on general tasks and duties such as written and oral communication, administration, and supervision. Specialised engineering tasks and duties such as civil engineering and electronic engineering were still performed, but they tended to provide relatively low contributions to the work of each cluster in this major group.

Space does not permit an examination of all the background variables for the intermediate and primary clusters, so only the following key background variables are examined:

- average age;
- percentage of females;
- average salary ($, 1985);
- number of States or Territories represented in the cluster;
- percentage of cluster having completed an engineering certificate qualification or higher.

The values of these variables for each intermediate and primary cluster within engineering systems and administration are given in Table 6.4. This table also includes job task information in the last five columns. The average figures shown in this table and subsequent tables provide only an approximate indication of population characteristics, due to sampling error. Caution should be exercised in interpretation, particularly with primary cluster values, as most primary clusters comprise very small numbers of respondents.

The location of each cluster in Table 6.4 may be related to the cluster diagram in Figure 6.2 as follows:

> Start at the top left of the cluster diagram (cluster 230) and then move horizontally to the right. Then move down one row and then move again to the right, as though reading a book.

Thus in Table 6.4 and subsequent tables intermediate clusters appear first, followed by the primary clusters.

The cluster titles were selected after examining the top 60 tasks in the job description (given in Appendix E) and the key background variables. The titles selected are descriptive and have no industrial or legal status. They are meant to be descriptive of the types of tasks undertaken. Some general terms and their use in these titles are:

- supervisors - indicates that supervision tasks contribute a large part;
- senior - indicates that supervision tasks contribute a moderate part;
- officers - indicates primarily engineering associate level;
- technicians - indicates primarily engineering technician level.

TABLE 6.4 SOME BACKGROUND INFORMATION ON CLUSTERS WITHIN ENGINEERING SYSTEMS AND ADMINISTRATION

CLUSTER NUMBER	TITLE OF CLUSTER	NUMBER OF RESPONDENTS	AVERAGE AGE	PERCENT FEMALE	AVERAGE SALARY	NUMBER OF STATES*	EDUCATION* - % certific	TASK LEVEL INDEX*	AVERAGE NO. OF TASKS	CLUSTER LEVEL*	AREA OF SPECIALISATION*	JOB PROFILE PAGE NO.
230	ENGINEERING OFFICE ADMINISTRATION AND DRAFTING	108	34	3.7	23,300	8	72	65	75	A	M	-
212	ENGINEERING SUPERVISION	124	41	0.0	27,400	8	62	68	94	A	ME	-
173	PRODUCTION CONTROL	68	33	0.0	25,500	7	70	65	181	A	ME	-
137	ELECTRICAL PLANNING & DESIGNING	37	36	0.0	23,700	7	70	66	84	A	E	-
269	ESTIMATION & QUALITY CONTROL	57	34	3.6	22,700	8	66	64	63	A	M	-
255	ENGINEERING DESIGN DRAFTING	51	34	3.9	24,100	8	80	65	87	A	M	-
419	SENIOR ENGINEERING SUPERVISION	66	42	0.0	28,500	8	72	69	96	A	M	-
146	MATERIALS TESTING	52	34	3.9	22,600	7	70	62	76	A	M	-
185	CONTROL SYSTEMS	35	34	0.0	25,400	6	74	65	158	A	ME	-
87	OTHER ENGINEERING ADMINISTRATORS	32	37	3.2	24,600	6 N	63	63	41	A	M	-
414	ESTIMATORS	25	34	4.0	22,700	7	58	64	61	A	G	-
311	QUALITY CONTROLLERS	16	32	0.0	24,400	6	81	65	75	A	M	-
393	DESIGN DRAFTERS	29	32	3.5	23,300	5	76	64	92	A	M	-
453	ENG. SAFETY & MAINT. SUPERVISORS	56	40	0.0	28,200	8	73	68	101	A	M	-
422	MICROELECTRONIC ENGINEERING SUPERVISORS	22	41	0.0	26,700	5	55	68	121	A	E	-
347	OTHER ENGINEERING SUPERVISORS	21	40	0.0	25,500	7	29	66	75	B	M	-
172	INSPECTORS	19	34	10.5	22,900	4	78	64	70	A	M	-
254	ELECTRICAL SUPPLY CONTROLLERS	33	33	0.0	25,700	7 N	68	64	205	A	ME	-
571	ENGINEERING ESTIMATORS	10	33	10.0	22,600	5	44	63	57	B	E	-
502	MECHANICAL & OTHER DESIGN DRAFTERS	20	32	5.0	23,000	5	75	64	90	A	M	-
516	OTHER DESIGN DRAFTERS	13	32	7.7	22,500	5	77	62	83	A	M	-
435	Electrical Designers	14	40	0.0	24,800	6	79	67	108	A	E	190
565	Electrical Contracts Supervisors	5	42	0.0	24,100	3	60	69	83	A	E	191
309	Electrical Equipment Drafters	6	29	0.0	24,000	3	67	62	75	A	E	192
240	Planners of new electricity supply	9	31	0.0	22,200	5	67	66	62	A	EC	193
521	Building Services Estimators	5	23	20.0	14,500	4	80	63	66	A	G	194
574	Construction Contract Estimators	13	35	0.0	22,800	6	69	66	68	A	G	195
671	Electrical Engineering Estimators	5	30	0.0	21,100	3	20	65	60	B	EC	196
640	Civil Engineering Estimators	5	37	20.0	24,100	4	75	62	53	A	G	197
449	Construction Site Supervisors	6	54	0.0	24,000	3 T	50	65	41	A	G	198
444	Quality Control Specialists	5	36	0.0	24,100	4	80	66	67	A	G	199
457	Quality & Equipment Monitors	7	30	0.0	24,800	4 N	71	64	83	A	M	200
305	Building Services Designers	17	36	5.9	24,600	7	80	66	76	A	ME	201
448	Construction Design Drafters	9	33	0.0	23,800	4 N	78	64	94	A	M	202
664	Mechanical Design Drafters	7	32	0.0	23,900	4	71	66	104	A	MC	203
616	Design Drafters (non-computerised)	8	31	12.5	22,400	5	88	63	75	A	M	204
657	Design Drafters (computerised)	5	33	0.0	22,800	4	60	61	95	A	MC	205
299	Senior Hydrology Technical Officers	5	39	0.0	27,100	3	100	69	102	A	MEC	206
469	Civil/Structural Eng. Supervisors	10	49	0.0	30,700	5	70	72	69	A	C	207
713	Transport & Civil Engineering Supervisors	14	40	0.0	27,800	6	50	68	135	A	M	208
769	General Engineering Supervisors	17	41	0.0	29,700	6	80	69	87	A	G	209
652	Engineering Survey/Mapping Supervisors	5	42	0.0	31,300	5	100	70	82	A	C	210
609	Electronic Engineering Supervisors	9	44	0.0	28,400	5	71	69	79	A	ME	211
596	Quality Supervisors	7	38	0.0	23,000	4	83	66	94	A	M	212
792	Microelectronic Technician Supervisors	9	43	0.0	27,800	3	22	68	119	B	E	213
840	Computer Technician Supervisors	5	40	0.0	24,100	3 S	60	67	147	A	E	214
357	Trade Supervisors	16	37	0.0	24,400	5	25	65	66	B	G	215
461	Senior Safety Officers	5	47	0.0	28.900	4	40	68	103	B	M	216
402	Survey Engineering Supervisors	5	43	0.0	25,300	3 N	100	69	77	A	C	217
277	Senior Production & Engineering Quality Controllers	6	39	0.0	26,500	5	50	69	53	A	MC	218
632	Materials Test Tech./Officers	6	30	0.0	19,000	4	60	58	78	A	M	219
703	Materials Test Officers	8	33	0.0	25,000	4	83	63	93	A	M	220
349	General Test Tech./Officers	6	30	0.0	19,500	4	60	57	57	A	ME	221
182	Site Inspectors/Testers	7	28	14.3	21,800	4	100	64	62	A	C	222
232	Inspectors/Recorders	12	37	8.3	23,500	3 N	67	63	75	A	M	223
135	Cartographic Survey Supervisors*	12	41	0.0	28,500	5	67	67	53	A	MC	224
526	Senior Electric Supply Controllers	14	36	0.0	27,400	5	58	64	205	A	ME	225

CLUSTER NUMBER	TITLE OF CLUSTER	NUMBER OF RESPONDENTS	AVERAGE AGE	PERCENT FEMALE	AVERAGE SALARY	NUMBER OF STATES*	EDUCATION* - % certific	TASK LEVEL INDEX*	AVERAGE NO. OF TASKS	CLUSTER LEVEL*	AREA OF SPECIALISATION*	JOB PROFILE PAGE NO.
548	Electric Supply Controllers	10	29	0.0	24,100	3 N	90	63	255	A	ME	226
576	Electromechanical Engineering Officers	10	35	0.0	25,600	4 Q	67	66	222	A	ME	227
493	Mechanical Engineering Officers	9	36	0.0	24,500	4 V	56	65	131	A	M	228
234	Electromechanical Control System Designers	9	32	0.0	26,500	4 N	100	66	127	A	ME	229
267	Equipment Evaluation Officers	10	36	0.0	24,100	3 N	70	62	34	A	G	230
259	Production Engineering Officers	7	31	14.3	22,200	3 N	67	61	58	A	ME	231
190	Work Study Officers*	5	38	0.0	24,700	2 N	60	64	49	A	M	232
238	Aeronautical Engineering Technicians	8	42	0.0	28,000	3 N	50	64	31	T	M	233

*NOTES

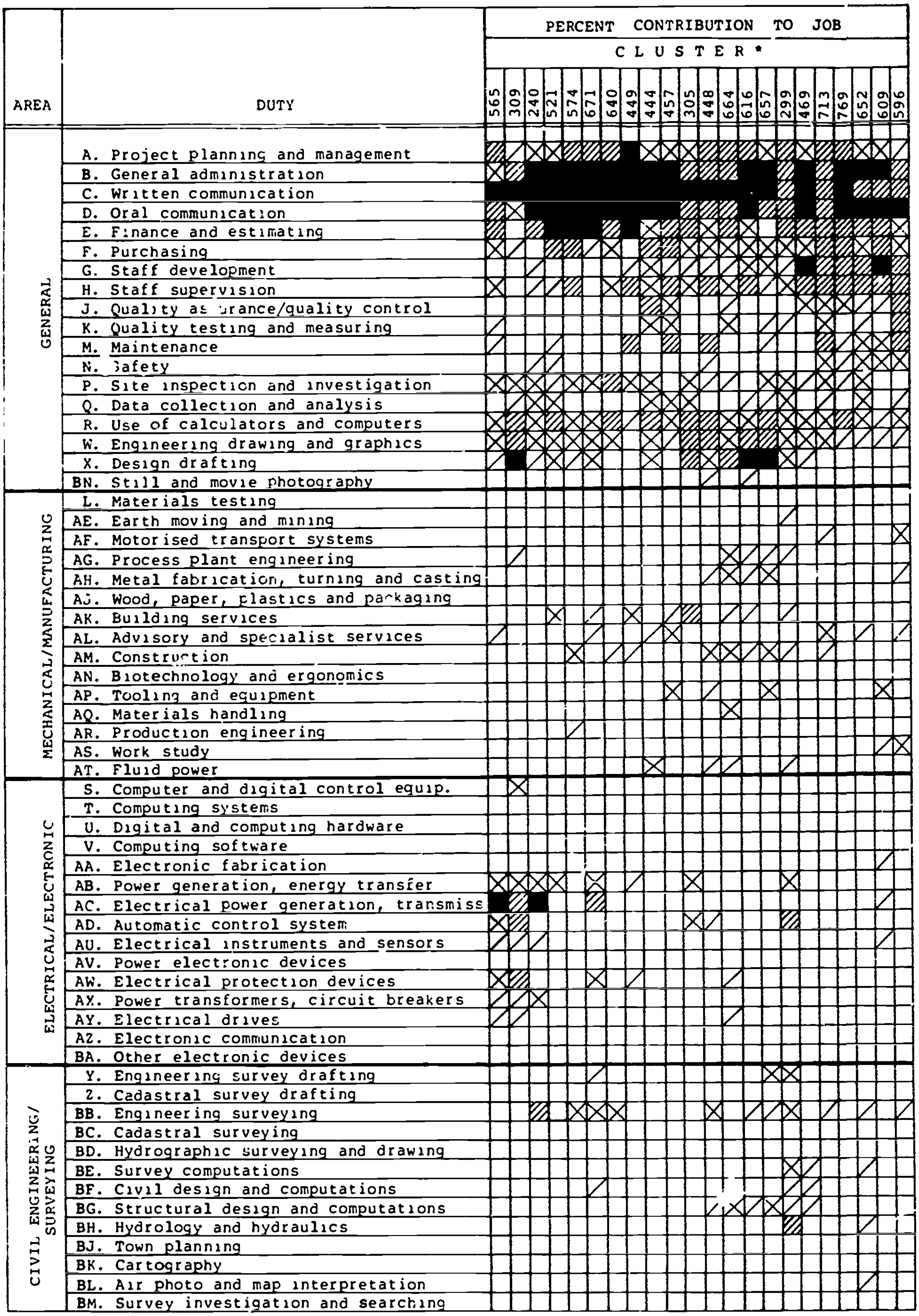
1. Cluster titles in capital letters indicate intermediate clusters, whereas cluster titles in lower-case letters indicate primary clusters. Cluster titles with an asterisk indicate the primary clusters that are regarded as marginal, having within group overlap indices of between 40% and 45%, or between groups overlap indices of between 25% and 30%.
2. States - Indicates the number of States or Territories represented in the cluster. Also indicated is the State or Territory representing over 40% of the members of intermediate clusters and over 50% of the members of primary clusters, where N = NSW, V = VIC, Q = Qld, S = SA, W = WA, T = TAS, A= ACT.
3. Education indicates the percentage of members of the cluster who have completed a certificate course in engineering or higher qualification.
4. Task level index indicates the average level of tasks performed by members of the cluster. The minimum 0 indicates all tasks are performed by technician level workers or tradespersons. The maximum of 100 indicates that all tasks are performed by associate level workers or professional engineers. The actual range for all clusters is 47 to 72.
5. Level indicates the likely average level of the cluster, based on the variables of highest education, task level index, and number of tasks performed. A = associate level, T = technician level, B = blurred (probable mixture of both levels).
6. Area of specialisation indicates the main area(s) of specialisation of the cluster, where m = over 6% contribution from mechanical/manufacturing area, E = over 6% contribution from electrical/electronic area, C = over 6% contribution from civil engineering/surveying area, and G = general area, with less than 6% contribution in each of the other three areas.
7. Page number of job description indicates the page number in Appendix E of the task level job description (top 60 tasks only) of each cluster.
8. Average figures provide only an approximate indication of population characteristics, due to sampling error. Caution should be exercised in interpretation, particularly with primary cluster values, as most primary clusters comprise very small numbers of respondents.

AREA	DUTY	PERCENT CONTRIBUTION TO JOB CLUSTER*																					
		230	212	173	137	269	255	419	146	185	87	414	311	393	453	422	347	172	254	571	502	516	435
GENERAL	A. Project planning and management	▨	▨	X	X	▨	X	X	X	X	X	▨	▨	▨	X	▨	X	X	X	▨	▨	▨	/
	B. General administration	■	■	▨	▨	■	▨	■	▨	▨	■	■	■	■	■	■	■	▨	▨	■	■	■	X
	C. Written communication	■	■	▨	■	■	■	■	■	▨	■	■	■	■	■	■	■	■	▨	■	■	■	■
	D. Oral communication	■	■	▨	▨	■	▨	■	■	▨	■	■	■	▨	■	▨	■	■	▨	■	▨	■	▨
	E. Finance and estimating	▨	▨	X	▨	▨	X	▨	/	X	X	▨	▨	X	▨	▨	/	/	X	▨	X	/	▨
	F. Purchasing	▨	X	X	X	▨	X	X	X	X	X	▨	▨	X	▨	X		X	X	X	X	X	X
	G. Staff development	/	▨	X	/	/	/	▨	X	X	/		X	/	▨	▨	■	/	/		/	/	/
	H. Staff supervision	X	▨	X	X	X	X	▨	X	X	/	X	X	X	▨	X	▨	/	X	/	X	X	X
	J. Quality assurance/quality control		X	/		/		X	X	X	/		X		X		/		/				
	K. Quality testing and measuring	/	X	X		/		/	▨	X	X		X	/	X	X	X	X	/		/		
	M. Maintenance	X	X	X		X	/	X	X	X			X	X	X	X	X	/	X				
	N. Safety		X	/				X	/	/	/			/	X		▨		/				
	P. Site inspection and investigation	X	/	/	X	X	X	/	X	/	/	X	/	/	X	/	/	▨	/	▨	/	/	X
	Q. Data collection and analysis	/	/	/	/	/	/	/	▨	/	X	/	X	/	/	/	X	▨	/	/	/	/	X
	R. Use of calculators and computers	X	X	X	▨	X	▨	X	▨	X	▨	X	▨	X	X	X	▨	■	X	X	X	X	▨
	W. Engineering drawing and graphics	X	/	X	▨	X	▨	X	X	X	X	X	X	▨	/	X		X	/	X	▨	▨	▨
	X. Design drafting	X		X	▨	/	▨		/	X	/	/	/	▨		X		X	/	/	▨	■	▨
	BN. Still and movie photography								/									X					
MECHANICAL/MANUFACTURING	L. Materials testing								X														
	AE. Earth moving and mining																						
	AF. Motorised transport systems									/													
	AG. Process plant engineering			/			/			/				/					/		X	/	
	AH. Metal fabrication, turning and casting			/			/			X				X							X	X	
	AJ. Wood, paper, plastics and packaging																						
	AK. Building services	X		/	/	/	X			/									/		/		/
	AL. Advisory and specialist services		/	X				/	/	X	X		X		/		X	X	/				
	AM. Construction	/		/		/	/			/		/		X							X	/	
	AN. Biotechnology and ergonomics																						
	AP. Tooling and equipment			X					/	▨			/			/	/	X				/	
	AQ. Materials handling									/											/		
	AR. Production engineering			/						/													
	AS. Work study									/	/												
	AT. Fluid power			/			/			X			/	/									
ELECTRICAL/ELECTRONIC	S. Computer and digital control equip.			/												/			X				
	T. Computing systems																	/					
	U. Digital and computing hardware		/	/												▨			X				
	V. Computing software																						
	AA. Electronic fabrication															/							
	AB. Power generation, energy transfer	/		X	X	/	/			/			/						X	/			X
	AC. Electrical power generation, transmiss			X	■	/		/		/	/	/			/				▨	X			■
	AD. Automatic control system	/		X	X		X			/			/						▨				X
	AU. Electrical instruments and sensors			X	X				/	/						/			X				/
	AV. Power electronic devices			/												/			X				
	AW. Electrical protection devices			X	X						/					/			▨	/			▨
	AX. Power transformers, circuit breakers			/	X														X				X
	AY. Electrical drives			X	/					/									X				/
	AZ. Electronic communication		/													▨							
	BA. Other electronic devices															X			/				
CIVIL ENGINEERING/SURVEYING	Y. Engineering survey drafting																						
	Z. Cadastral survey drafting																						
	BB. Engineering surveying	/			/	/	/			/		X		/				/		X		/	
	BC. Cadastral surveying																						
	BD. Hydrographic surveying and drawing																						
	BE. Survey computations																						
	BF. Civil design and computations																						
	BG. Structural design and computations						/							X							X	/	
	BH. Hydrology and hydraulics																						
	BJ. Town planning																						
	BK. Cartography																						
	BL. Air photo and map interpretation																						
	BM. Survey investigation and searching																						

NOTE: 1. The titles of each of these clusters are given in Table 6.4 and Figure 6.2.

2. ☐ = 0 to 1% contribution to job; / = 1 to 2% contribution to job; X = 2 to 5% contribution to job; ▨ = 5 to 10% contribution to job; ■ = over 10% contribution to job;

Figure 6.17 Duty level job descriptions for clusters within engineering systems and administration



***NOTE**: 1. The titles of each of these clusters are given in Table 6.4 and Figure 6.2.

2. ☐ = 0 to 1% contribution to job; ▨ = 5 to 10% contribution to job;
⧄ = 1 to 2% contribution to job; ■ = over 10% contribution to job;
☒ = 2 to 5% contribution to job;

Figure 6.17 (Continued)

AREA	DUTY	792	840	357	461	402	277	632	703	349	182	232	135	526	548	576	493	234	267	259	190	238
GENERAL	A. Project planning and management	▨	▨	▨	X	▨	X	/	/		X	/	X	X	X	X	X	X	/	X	X	
	B. General administration	■	▨	■	■	▨	■	▨	▨	▨	▨	▨	■	▨	X	▨	▨	▨	■	■	▨	■
	C. Written communication	■	■	■	■	▨	■	▨	▨	■	■	■	■	▨	X	▨	▨	▨	■	■	■	■
	D. Oral communication	▨	▨	■	■	■	■	▨	▨	▨	■	■	■	▨	X	▨	▨	▨	■	■	■	■
	E. Finance and estimating	▨	▨	/	/	X	▨		X			/	X	X	/	X	▨	X	▨	X	X	
	F. Purchasing	X	X		/	X	▨	X	X	X	X	X	/	X	X	X	X	X	▨	X		
	G. Staff development	▨	X	■	▨	X	▨	X	▨			/	X	X	/	X	▨		X		X	X
	H. Staff supervision	▨	X	▨	X	▨	▨	▨	X		X		▨	X	X	X	X	X			X	X
	J. Quality assurance/quality control		/	X		X	■	X	▨	X			/			X	X	/		X		X
	K. Quality testing and measuring	X	X	X	X	X	/	■	■	■	X	X		/	/	X	X	X		X	/	X
	M. Maintenance	X	X	X	/	▨		▨	▨	/		X	/	X	X	X	X	X		▨		▨
	N. Safety	/	/	▨	▨	X			/	/		/		/	/	/	X				/	X
	P. Site inspection and investigation	/			/	■		▨	X		■	/	/	X	/	/		/	/		/	/
	Q. Data collection and analysis	/	X	X	X			▨	▨	■	▨	▨		/	/	X	/	X	/	/	▨	/
	R. Use of calculators and computers	X	▨	▨	▨	X	X	▨	▨	▨	▨	■	▨	X	/	X	/	X	▨	▨	▨	X
	W. Engineering drawing and graphics	X	/					X	/	X	/	▨	/	X	/	X	X	X	/	X	▨	/
	X. Design drafting	/	/									X		X	/	/	X		/		X	
	BN. Still and movie photography				/					/	X	X										
MECHANICAL/MANUFACTURING	L. Materials testing							▨	▨	X												
	AE. Earth moving and mining					/															/	
	AF. Motorised transport systems											/	X					X				X
	AG. Process plant engineering						/				/				X	X						
	AH. Metal fabrication, turning and casting						/									/	X					
	AJ. Wood, paper, plastics and packaging																/					
	AK. Building services													/				X				
	AL. Advisory and specialist services	/			▨						/	X		/	/	X	/	X			/	■
	AM. Construction				X	X								/		X		X				
	AN. Biotechnology and ergonomics																					
	AP. Tooling and equipment	/			/		X			X		X			/	X	▨	/		X		
	AQ. Materials handling															/	/					
	AR. Production engineering						X						/			/	X			/		
	AS. Work study												/			/	/				▨	
	AT. Fluid power															/		X				
ELECTRICAL/ELECTRONIC	S. Computer and digital control equip.		/								/			/	X							
	T. Computing systems		/								/											
	U. Digital and computing hardware	X	■								/			/	X							
	V. Computing software		/									/										
	AA. Electronic fabrication	/	X	/																		
	AB. Power generation, energy transfer												/	X	X	/		X				
	AC. Electrical power generation, transmiss													▨	▨			/		X		
	AD. Automatic control system													X	▨	/		X			/	
	AU. Electrical instruments and sensors	/	/						/	▨		/		X	X	/		/				
	AV. Power electronic devices		X							/				X	X	/						
	AW. Electrical protection devices		/											▨	▨	/				X		
	AX. Power transformers, circuit breakers													/	X	/						
	AY. Electrical drives													X	▨	X						
	AZ. Electronic communication	▨	▨		/																	
	BA. Other electronic devices	X	X												/							
CIVIL ENGINEERING/ SURVEYING	Y. Engineering survey drafting																					
	Z. Cadastral survey drafting												/									
	BB. Engineering surveying					X		/			/	/				/		/				
	BC. Cadastral surveying																					
	BD. Hydrographic surveying and drawing																					
	BE. Survey computations					X		/														
	BF. Civil design and computations					/																
	BG. Structural design and computations																				/	
	BH. Hydrology and hydraulics																	X				
	BJ. Town planning																					
	BK. Cartography						/						X									
	BL. Air photo and map interpretation										/											
	BM. Survey investigation and searching						/						/									

(Column heading over the cluster numbers: PERCENT CONTRIBUTION TO JOB — CLUSTER*)

***NOTE:** 1. The titles of each of these clusters are given in Table 6.4 and Figure 6.2.

2. ☐ = 0 to 1% contribution to job; / = 1 to 2% contribution to job; X = 2 to 5% contribution to job; ▨ = 5 to 10% contribution to job; ■ = over 10% contribution to job;

Figure 6.17 (Continued)

An examination of the cluster titles in Table 6.4 gives an indication of the range of clusters within the major cluster of engineering systems and administration. All of the main branches of engineering are represented, along with many small or more peripheral branches such as estimation, quality control, production control and aeronautical engineering.

Some of the more interesting results in Table 6.4 are:

- the primary clusters range in size from 5 respondents to 17 respondents; while the intermediate clusters range in size from 10 respondents to 124 respondents;
- the average age of each cluster ranges from 23 years (cluster 521: building services estimators) to 54 years (cluster 449: construction site supervisors);
- the percentage of females in each cluster ranges from 0% in a large number of clusters to a maximum of 20% in two clusters;
- the average salary ranges from $14,500 (cluster 521: building services estimators) to $30,700 (cluster 469: civil/structural engineering supervisors);
- the percentage of members of the cluster completing an engineering certificate or higher qualification ranges from 19% (cluster 357: trade supervisors) to 100% for three clusters;
- the task level index ranges from 57 (cluster 349: general test technicians/officers) to 72 (cluster 469: civil/structural engineering supervisors);
- the average number of tasks performed by each cluster ranges from 31 (cluster 238: aeronautical engineering technicians) to 255 (cluster 548: electric supply controllers).

Table B-8 in Appendix B gives the percentage contribution in each of the four broad job function areas for each cluster.

The duty level job descriptions in Figure 6.17 provide an overview of the duties providing high contributions to the work of each cluster, and clearly show the importance of duties in the general area for all of these clusters.

To obtain an accurate description of the job profile of each cluster, one needs to refer to the task level job descriptions in Appendix E.

A good example of where the task profile in Appendix E shows a clear difference between two adjacent clusters while the duty

profile in Figure 6.17 shows little apparent difference, is the two adjacent clusters, cluster 616 - design drafters (non-computerised) and cluster 657 - design drafters (computerised).

6.7 CLUSTERS WITHIN CIVIL ENGINEERING AND SURVEYING

There were 21 primary and 10 intermediate clusters found within civil engineering and surveying. Figure 6.3 shows the titles of these clusters and the linkages between the primary and intermediate clusters.

As shown in Figure 6.3 the major cluster divided into the following main groups:

- cluster 197 - civil engineering (202 respondents)
- cluster 196 - cartographic and survey analysis (19 respondents)
- cluster 198 - structural engineering design and drafting (23 respondents)
- cluster 261 - engineering survey assistants (17 respondents)
- cluster 194 - survey assistants (27 respondents)
- cluster 128 - engineering technician survey drafting (26 respondents)

In addition to these main groups, a number of primary clusters that are traditionally classified within civil engineering and surveying are to be found in the adjacent major clusters. That is, if there is a high contribution of supervision, administration, and/or general engineering duties, some traditional civil engineering and surveying clusters were included in engineering systems and administration, shown in Figure 6.2. Also, if there is a high contribution of design and drafting duties, some traditional civil engineering and surveying clusters were included in or near the major cluster of design and drafting, shown in Figure 6.4.

The values of some key background variables and task variables for each primary and intermediate cluster within civil engineering and surveying are given in Table 6.5. Some of the more interesting results in Table 6.5 are:

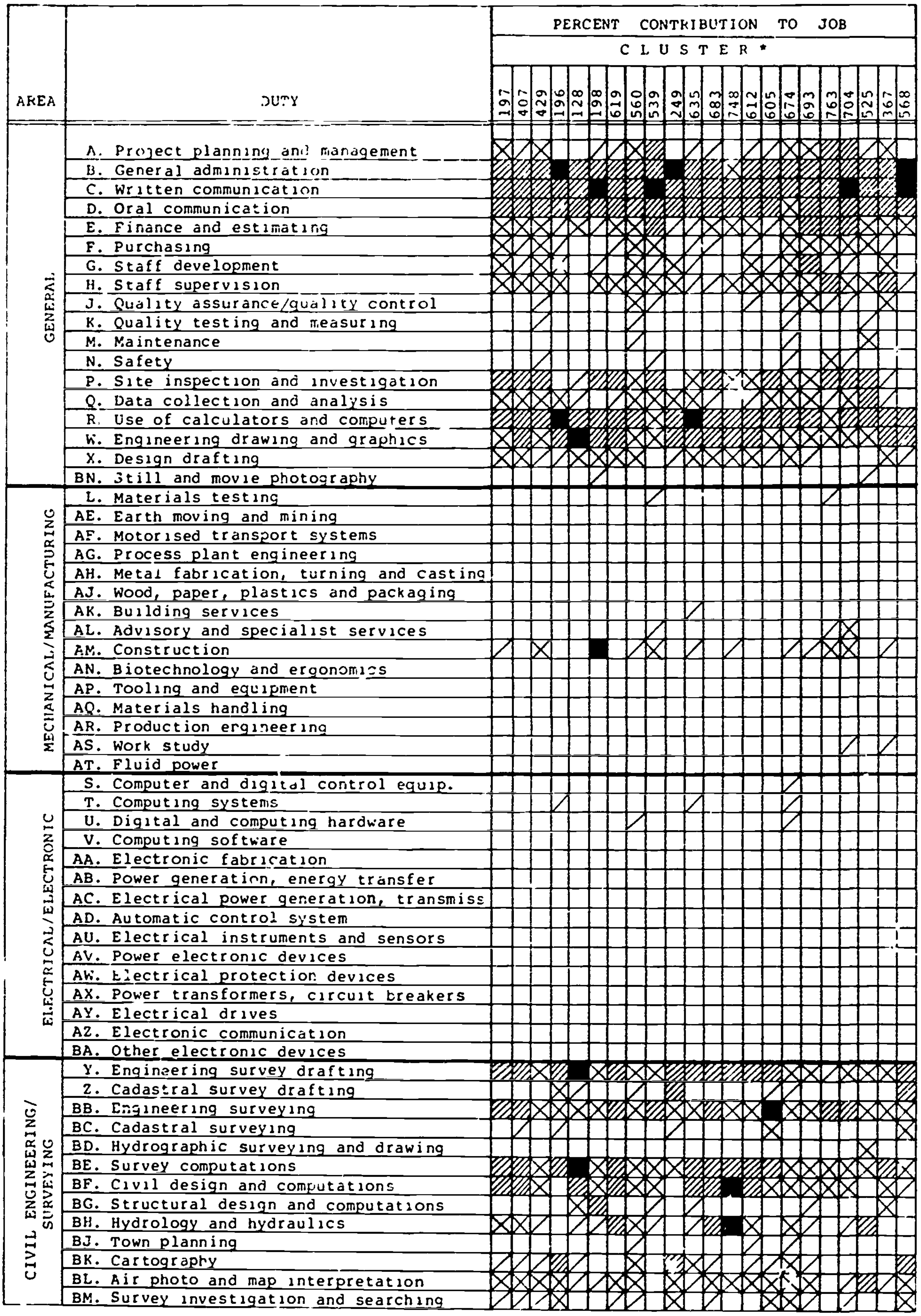
- the primary clusters range in size from 5 respondents to 27 respondents; while the intermediate clusters range in size from 13 respondents to 202 respondents;

TABLE 6.5 SOME BACKGROUND INFORMATION ON CLUST 'S WITHIN CIVIL ENGINEERING AND SURVEYING

CLUSTER NUMBER	TITLE OF CLUSTER	NUMBER OF RESPONDENTS	AVERAGE AGE	PERCENT FEMALE	AVERAGE SALARY	NUMBER OF STATES*	EDUCATION* - % certific	TASK LEVEL INDEX*	AVERAGE NO. OF TASKS	CLUSTER LEVEL*	AREA OF SPECIALISATION*	JOB PROFILE PAGE NO.
197	CIVIL ENGINEERING	202	34	2.0	23,500	8	83	65	114	A	C	-
407	ENGINEERING ASSOCIATE SURVEY DRAFTING	118	31	2.6	21,700	8	83	64	100	A	C	-
429	CIVIL ENGINEERING SUPERVISION	63	36	1.6	26,300	7	84	67	147	A	C	-
136	CARTOGRAPHIC & SURVEY ANALYSIS	19	32	15.8	21,500	5 V Q	89	57	73	A	C	-
128	ENGINEERING TECHNICIAN SURVEY DRAFTING	26	29	15.4	19,500	5 Q	58	58	40	B	C	-
198	STRUCTURAL ENGINEERING DESIGN AND DRAFTING	23	33	4.4	23,600	8	91	67	73	A	MC	-
619	CIVIL DESIGN & DRAFTING	66	31	1.6	21,400	7	88	65	96	A	C	-
560	CIVIL ENGINEERING OFFICE SUPERVISION	38	36	2.6	27,000	7	74	67	172	A	C	-
539	CIVIL ENGINEERING SITE SUPERVISION	25	36	0.0	25,300	6 N	100	67	110	A	MC	-
249	CARTOGRAPHY	13	32	23.1	21,200	5 V	83	54	71	A	C	-
635	Senior Engineering Survey Drafters	9	28	11.1	20,800	3	75	61	95	A	C	234
683	Civil Design & Drafting Officers	58	31	1.8	21,300	7	86	64	99	A	C	235
748	Water Storage/Drainage Design and Drafting Officers	8	32	0.0	21,600	2 Q	100	69	72	A	C	236
612	Civil Design & Drafting Supervisors	13	38	0.0	25,400	5	92	68	117	A	C	237
605	Survey Officers	25	30	4.0	22,300	6	79	62	107	A	C	238
674	Civil Engineering Office Supervisors	21	35	4.8	26,200	6	76	67	199	A	C	239
693	Senior Civil Engineering Office Supervisors	13	40	0.0	30,000	5	77	69	141	A	C	240
763	Civil Engineering Site Supervisors	18	36	0.0	26,200	6	100	67	107	A	MC	241
704	Civil Engineering Site Officers	6	36	0.0	22,000	2 V	100	67	116	A	MC	242
525	Hydrological Analysis Officers	8	36	0.0	23,900	3	83	65	117	A	C	243
367	Civil Engineering Officers	7	42	0.0	26,900	3 Q	86	68	87	A	C	244
568	Cartographic Survey Drafting Officers	5	32	40.0	19,300	4	100	53	64	A	C	245
676	Cartographic Computation Officers	6	30	0.0	22,500	3	83	56	79	A	C	246
246	Survey Computation Officers	6	32	0.0	22,000	2 Q	100	63	79	A	EC	247
445	Structural Designers and Drafters	12	34	8.3	24,000	6	92	67	78	A	MC	248
471	Civil & Structural Designers and Drafters	5	32	0.0	23,500	3	100	64	75	A	MC	249
261	Engineering Survey Assistants	17	33	6.3	21,600	5 N	71	63	57	A	C	250
194	Survey Assistants	27	32	0.0	20,500	7	76	60	49	A	C	251
488	Road Survey Drafters	7	32	14.3	21,800	4	43	60	51	B	C	252
606	Survey Computation & Drafting Technicians	5	26	20.0	17,500	1 Q	60	59	32	B	C	253
338	Engineering Survey Drafters	7	28	14.3	16,600	5	20	54	37	T	C	254

*NOTES

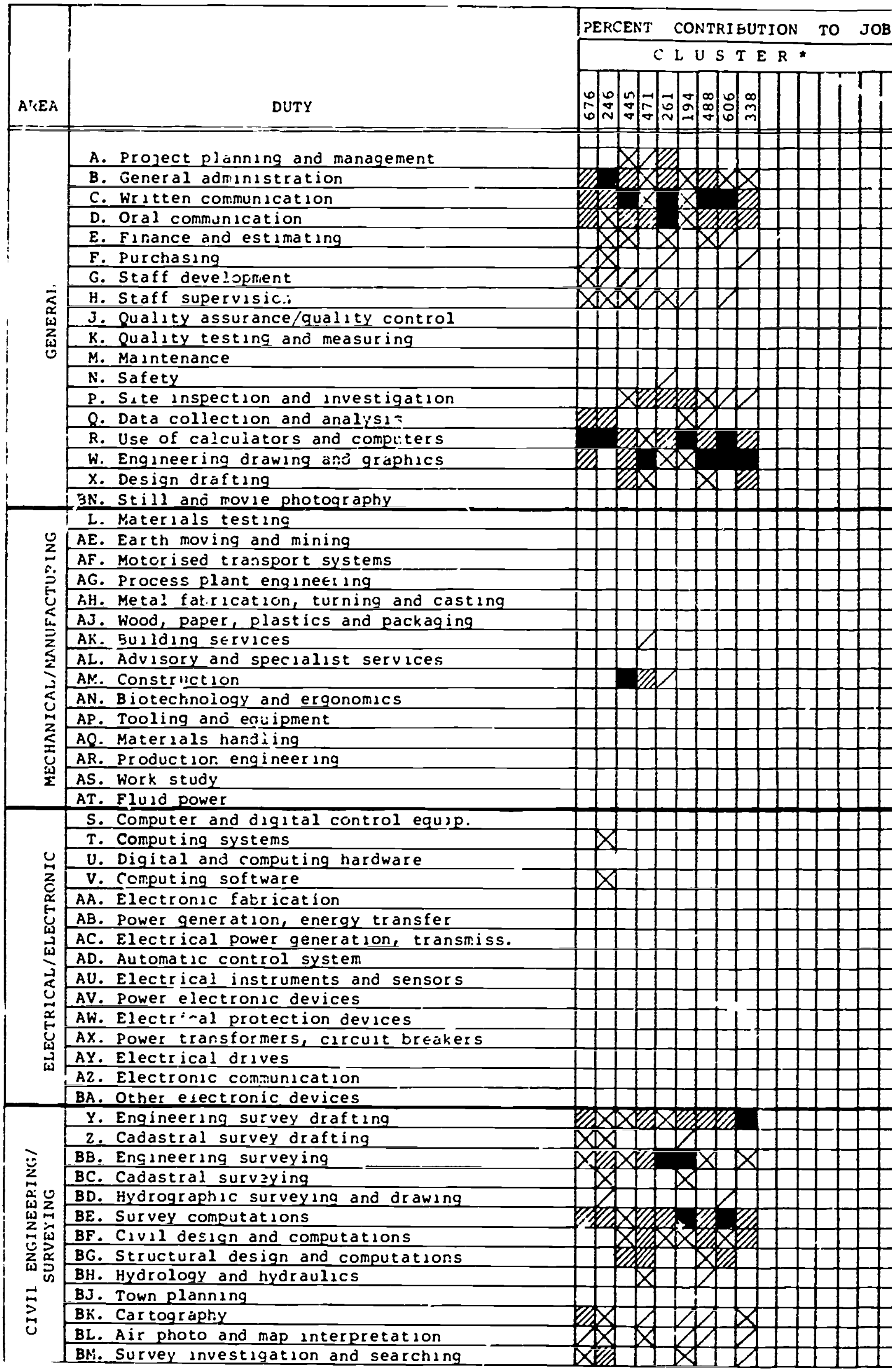
1. Cluster titles in capital letters indicate intermediate clusters, whereas cluster titles in lower-case letters indicate primary clusters. Cluster titles with an asterisk indicate the primary clusters that are regarded as marginal, having within group overlap indices of between 40% and 45%, or between groups overlap indices of between 25% and 30%.
2. States - Indicates the number of States or Territories represented in the cluster. Also indicated is the State or Territory representing over 40% of the members of intermediate clusters and over 50% of the members of primary clusters, where N = NSW, V = VIC, Q = Qld, S = SA, W = WA, T = TAS, A= ACT.
3. Education indicates the percentage of members of the cluster who have completed a certificate course in engineering or higher qualification.
4. Task level index indicates the average level of tasks performed by members of the cluster. The minimum 0 indicates all tasks are performed by technician level workers or tradespersons. The maximum of 100 indicates that all tasks are performed by associate level workers or professional engineers. The actual range for all clusters is 47 to 72.
5. Level indicates the likely average level of the cluster, based on the variables of highest education, task level index, and number of tasks performed. A = associate level, T = technician level, B = blurred (probable mixture of both levels).
6. Area of specialisation indicates the main area(s) of specialisation of the cluster, where m = over 6% contribution from mechanical/manufacturing area, E = over 6% contribution from electrical/electronic area, C = over 6% contribution from civil engineering/surveying area, and G = general area, with less than 6% contribution in each of the other three areas.
7. Page number of job description indicates the page number in Appendix E of the task level job description (top 60 tasks only) of each cluster.
8. Average figures provide only an approximate indication of population characteristics, due to sampling error. Caution should be exercised in interpretation, particularly with primary cluster values, as most primary clusters comprise very small numbers of respondents.



NOTE: 1. The titles of each of these clusters are given in Table 6.5 and Figure 6.3.

2. ☐ = 0 to 1% contribution to job; ◩ = 1 to 2% contribution to job; ☒ = 2 to 5% contribution to job; ▨ = 5 to 10% contribution to job; ■ = over 10% contribution to job;

Figure 6.18 Duty level job descriptions for clusters within civil engineering and surveying



NOTE: 1. The titles of each of these clusters are given in Table 6.5 and Figure 6.3.

2. ☐ = 0 to 1% contribution to job; ⧄ = 1 to 2% contribution to job; ☒ = 2 to 5% contribution to job; ▨ = 5 to 10% contribution to job; ■ = over 10% contribution to job;

Figure 6.18 (Continued)

- the average age of each cluster ranges from 26 years (cluster 606: survey computation and drafting technicians) to 42 years (cluster 367: civil engineering officers);
- the proportion of females in each cluster ranges from 0% in a large number of clusters to a maximum of 40% in cluster 568: cartographic survey drafting officers;
- the average salary ranges from $16,600 (cluster 338: engineering survey drafters) to $30,000 (cluster 693: senior civil engineering office supervisors);
- the percentage of members of the cluster completing an engineering certificate or higher qualification ranges from 14% (cluster 338: engineering survey drafters) to 100% for five primary clusters;
- the task level index ranges from 53 (cluster 568: cartographic survey drafting officers) to 69 (cluster 748: water storage/drainage design and drafting officers);
- the average number of tasks performed by each cluster ranges from 32 (cluster 606: survey computation and drafting technicians) to 199 (cluster 674: civil engineering officer supervisors).

Table B-9 in Appendix B gives the percentage contribution of each of the four broad job function areas for each cluster. The duty level job descriptions in Figure 6.18 provide an overview of the duties providing high contributions to the work of each cluster, and clearly show the importance of duties in the civil engineering/surv ing area for all of these clusters.

To obtain an accurate description of the job profile of each cluster, one needs to refer to the task level job descriptions in Appendix E.

The task level job descriptions in Appendix E and the background information in Table 6.5 confirmed the fairly clear division of engineering associate clusters from engineering technician clusters in the survey drafting occupations. The same sources confirmed the clear division of 'office' clusters from 'site' clusters in the civil engineering supervision occupations. These divisions are reflected in the cluster titles shown in Figure 6.4.

6.8 CLUSTERS WITHIN AND NEAR DRAFTING AND DESIGN

There were 13 primary and 6 intermediate clusters found within drafting and design, and one outlying primary cluster between the major cluster of civil engineering and surveying and the

major cluster of drafting and design. Figure 6.1 shows the titles of these clusters and the linkages between the primary and intermediate clusters.

As shown in Figure 6.4, the major clusters divided into the following main groups:

- cluster 159 - drafting (64 respondents)
- cluster 242 - equipment design (29 respondents)
- cluster 134 - civil design drafters (6 respondents)
- cluster 94 - production method designers and planners (7 respondents)
- cluster 127 - tooling and equipment technicians (7 respondents).

The values of some key background variables and task variables for each primary and intermediate cluster within and near drafting and design are given in Table 6.6. Some of the more interesting results in Table 6.6 are:

- the primary clusters range in size from 5 respondents to 24 respondents; while the intermediate clusters range in size from 16 respondents to 64 respondents;
- the average age of each cluster ranges from 23 years (cluster 515: engineering survey drafters) to 37 years (cluster 126: senior structural analysis and design officers);
- the percentage of females in each cluster ranges from 0% in a large number of clusters to a maximum of 29% in cluster 515: engineering survey drafters;
- the average salary ranges from $16,600 (cluster 515: engineering survey drafters) to $28,900 (cluster 126: senior structural analysis and design officers);
- the percentage of members of the cluster completing an engineering certificate or higher qualification ranges from 29% (cluster 127: tooling and equipment technicians) to 100% (cluster 126: senior structural analysis and design officers);
- the task level index ranges from 49 (cluster 412: senior cartographic survey drafters) to 72 (cluster 126: senior structural analysis and design officers);
- the average number of tasks performed by each cluster ranges from 20 (cluster 389: other design drafters) to 65 (cluster 285: mechanical designers).

Table B-10 in Appendix B gives the percentage contribution of each of the four broad job function areas for each cluster.

TABLE 6.6 SOME BACKGROUND INFORMATION ON CLUSTERS WITHIN AND NEAR DRAFTING AND DESIGN

CLUSTER NUMBER	TITLE OF CLUSTER	NUMBER OF RESPONDENTS	AVERAGE AGE	PERCENT FEMALE	AVERAGE SALARY	NUMBER OF STATES*	EDUCATION* - % certific.	TASK LEVEL INDEX*	AVERAGE NO. OF TASKS	CLUSTER LEVEL*	AREA OF SPECIALISATION*	JOB PROFILE PAGE NO.
159	DRAFTING	64	27	9.5	19,400	7	69	55	36	B	C	-
278	DRAFTING ADMINISTRATION AND SURVEY DRAFTING	39	26	13.2	19,700	7	74	55	41	B	C	-
324	SURVEY DRAFTING	26	25	16.0	18,600	5	76	54	39	B	C	-
301	DESIGN DRAFTING	22	29	4.6	19,000	6 V	62	54	26	B	MC	-
242	EQUIPMENT DESIGN	29	30	0.0	21,800	5	90	61	61	A	MC	.
351	SENIOR SURVEY DRAFTERS	19	26	11.1	19,200	5	83	55	38	B	C	-
126	Senior Structural Analysis and Design Officers	5	37	0.0	28,900	2 Q	100	72	48	A	MC	255
478	Senior Electrical Design Drafters	7	29	0.0	22,200	5	86	56	44	B	E	256
513	Senior Electronic Design Drafters	6	29	16.7	21,500	4	50	56	47	T	G	257
515	Engineering Survey Drafters	7	23	28.6	16,600	3	57	52	41	B	C	258
497	Senior Engineering Survey Drafting Officc s	14	26	7.7	19,900	3	86	57	40	B	C	259
41?	Senior artographic Survey Drafters	5	26	20.0	17,500	4	75	49	33	B	C	260
542	Building Services Design Drafters	6	31	0.0	19,500	4	67	57	33	B	M	261
392	Structural Design Drafters	11	29	0.0	18,900	4 V	64	55	25	B	MC	262
389	Other De.ign Drafters	5	25	20.0	18,700	3	50	50	20	T	C	263
.85	Mechanical Designers	24	29	0.0	21,700	5	92	62	65	A	MC	264
406	Design and Development Officers	5	36	0.0	22,300	4	80	59	46	B	G	265
134	Civil Design Drafters*	6	27	0.0	20,500	3 V	67	62	35	A	C	266
94	Production Method Designers and Planners*	7	35	0.0	23,000	5	57	61	44	A	M	267
127	Tooling & Equipment Technicians*	7	27	0.0	17,000	3	29	56	38	T	M	268

*NOTES

1. Cluster titles in capital le..ers indicate intermediate clusters, whereas cluster titles in lower-case letters indicate primary clusters. Cluster titles with an asterisk indicate the primary clusters that are regarded as marginal, having within group overlap indices of between 40% and 45%, or between groups overlap indices of between 25% and 30%.
2. States - Indicates the number of States or Territories represented in the cluster. Also indicated is the State or Territory representing over 40% of the members of intermediate clusters and over 50% of the members of primary clusters, where N = NSW, V = VIC, Q = Qld, S = SA, W = WA, T = TAS, A= ACT.
3. Education indicates the percentage of members of the cluster who have completed a certificate course in engineering or higher qualification.
4. Task level index indicates the average level of tasks performed by members of the cluster. The minimum 0 indicates all tasks are performed by technician level workers or tradespersons. The maximum of 100 indicates that all tasks are performed by associate level workers or professional engineers. The actual range for all clusters is 47 to 72.
5. Level indicates the likely average level of the cluster, based on the variables of highest education, task level index, and number of tasks performed. A = associate level, T = technician level, B = blu..red (probable mixture of both levels).
6. Area of specialisation indicates the main area(s) of specialisation of the cluster, where m = over 6% contribution from mechanical/manufacturing area, E = over 6% contribution from electrical/electronic area, C = over 6% contribution from civil engineering/surveying area, and G = general area, with less than 6% contribution in each of the other three areas.
7. Page number of job description indicates the page number in Appendix E of the task level job description (top 60 tasks only) of each cluster.
8. Average figures provide only an approximate indication of population characteristics, due to sampling error. Caution should be exercised in interpretation, particularly with primary cluster values, as most primary clusters comprise very small numbers of respondents.

AREA	DUTY	PERCENT CONTRIBUTION TO JOB CLUSTER*																			
		159	278	324	301	242	351	126	478	513	515	497	412	542	392	389	285	406	134	94	127
GENERAL	A. Project planning and management	/	/	/		/	/	/			/	X					/	X		X	
	B. General administration	■	■	■	X	▨	■	X	■	▨	■	■	■	▨	X	/	▨	/	▨	▨	▨
	C. Written communication	■	■	■	■	■	■	■	■	■	■	■	■	■	■	▨	▨	■	■	▨	▨
	D. Oral communication	■	■	■	■	▨	■	▨	▨	▨	▨	■	■	■	■	■	▨	■	■	■	▨
	E. Finance and estimating					/		X						X			/		X	X	/
	F. Purchasing	/	/	/		X			X		X			X			X	▨	/	X	/
	G. Staff development		/	/			/			X		/						/		▨	
	H. Staff supervision	X	X	X		X	X	X	▨	X		X	/	/			X		X	▨	
	J. Quality assurance/quality control							/										X		X	
	K. Quality testing and measuring					/												▨		X	X
	M. Maintenance							/										X			X
	N. Safety																				
	P. Site inspection and investigation	/	/	/	/	/		X			X	/		X			/	/	▨		
	Q. Data collection and analysis				/			X		/	/				X		/		▨		
	R. Use of calculator and computers	▨	▨	▨	▨	▨	▨	■	▨	■	X	X	■	▨	▨	■	X	▨	▨	X	■
	W. Engineering drawing and graphics	■	■	■	■	■	■	▨	■	■	■	■	■	■	■	■	■	■	▨	▨	▨
	X. Design drafting	■	▨	▨	■	■	▨	X	■	■	X	▨	▨	■	■	■	■	■	/	X	▨
	BN. Still and movie photography																				
MECHANICAL/MANUFACTURING	L. Materials testing																	/			
	AE. Earth moving and mining					/											X				
	AF. Motorised transport systems					/												X			
	AG. Process plant engineering					/											/				
	AH. Metal fabrication, turning and casting					▨									/		▨	/		X	X
	AJ. Wood, paper, plastics and packaging									/					/						/
	AK. Building services				X									▨					X		
	AL. Advisory and specialist services							/													
	AM. Construction			/		X		■			/	/					X				
	AN. Biotechnology and ergonomics																				
	AP. Tooling and equipment				/										X					X	■
	AQ. Materials handling					/											X				/
	AR. Production engineering																			X	
	AS. Work study																				/
	AT. Fluid power					X											X				▨
ELECTRICAL/ELECTRONIC	S. Computer and digital control equip.																				X
	T. Computing systems																				
	U. Digital and computing hardware																				X
	V. Computing software																				
	AA. Electronic fabrication									X										/	
	AB. Power generation, energy transfer																				
	AC. Electrical power generation, transmiss.								X												
	AD. Automatic control system								/												
	AU. Electrical instruments and sensors																			X	
	AV. Power electronic devices																				
	AW. Electrical protection devices								X												
	AX. Power transformers, circuit breakers																				
	AY. Electrical drives					X								/			X				
	AZ. Electronic communication																				
	BA. Other electronic devices																				
CIVIL ENGINEERING/SURVEYING	Y. Engineering survey drafting	X	▨	▨	/		X			/	■	▨				X			▨		
	Z. Cadastral survey drafting										/										
	BB. Engineering surveying	/	/	X		/	/	/			X	X					/		X		
	BC. Cadastral surveying										/								X		
	BD. Hydrographic surveying and drawing																				
	BE. Survey computations	/	/	X	/		X				/	X				▨			/		
	BF. Civil design and computations							X				/							X		
	BG. Structural design and computations	/			X	X		■							▨		X				
	BH. Hydrology and hydraulics																	/			
	BJ. Town planning																				
	BK. Cartography			/			/						X						/		
	BL. Air photo and map interpretation										/										
	BM. Survey investigation and searching																				

NOTE 1. The titles of each of these clusters are given in Table 6.6 and Figure 6.4.

2. ☐ = 0 to 1% contribution to job; ▨ = 5 to 10% contribution to job;
/ = 1 to 2% contribution to job; ■ = over 10% contribution to job;
X = 2 to 5% contribution to job;

Figure 6.19 Duty level job descriptions for clusters within and near drafting and design

The duty level job descriptions in Figure 6.19 provide an overview of the duties providing high contributions to the work of each cluster, and clearly show the importance of the two duties 'W. engineering drawing and graphics' and 'X. design drafting' for all of these clusters.

To obtain an accurate description of the job profile of each cluster, one needs to refer to the task level job descriptions in Appendix E.

6.9 CLUSTERS WITHIN AND NEAR ELECTRICAL AND ELECTRONIC ENGINEERING

There were 18 primary and 7 intermediate clusters found within electrical and electronic engineering, and one outlying intermediate cluster with two outlying primary clusters adjacent to the major cluster. Figure 6.5 shows the titles of these clusters and the linkages between the primary and intermediate clusters.

As shown in Figure 6.5, the major cluster divided into the following main groups:

- cluster 67 - electrical engineering (32 respondents)
- cluster 89 - electronic engineering (126 respondents)
- cluster 56 - electronic testing and supervision (19 respondents).

In addition, there was one outlying intermediate cluster:

- cluster 16 - equipment assembly and repair (54 respondents).

The values of some key background variables and task variables for each primary and intermediate cluster within and near electrical and electronic engineering are given in Table 6.7. Some of the more interesting results in Table 6.7 are:

- the primary clusters range in size from 5 respondents to 17 respondents; while the intermediate clusters range in size from 11 respondents to 126 respondents;
- the average age of each cluster ranges from 25 years (cluster 216: computer and digital control technicians) to 37 years (cluster 183: equipment monitors and maintainers);

TABLE 6.7 SOME BACKGROUND INFORMATION ON CLUSTERS WITHIN AND NEAR ELECTRICAL AND ELECTRONIC ENGINEERING

CLUSTER NUMBER	TITLE OF CLUSTER	NUMBER OF RESPONDENTS	AVERAGE AGE	PERCENT FEMALE	AVERAGE SALARY	NUMBER OF STATES*	EDUCATION* - % certific	TASK LEVEL INDEX*	AVERAGE NO. OF TASKS	CLUSTER LEVEL*	AREA OF SPECIALISATION*	JOB PROFILE PAGE NO.
89	ELECTRONIC ENGINEERING	126	30	0.8	21,900	8	48	61	103	B	E	-
67	ELECTRICAL ENGINEERING	32	33	0.0	25,200	8 V	55	59	86	A	ME	-
120	ELECTRONIC EQUIPMENT	79	30	0.0	21,900	8	47	62	129	B	E	-
115	COMPUTER & DIGITAL EQUIPMENT	45	31	2.3	21,700	8	50	58	57	T	E	-
85	ELECTRICAL MONITORING	20	35	0.0	26,200	7 V	55	59	91	A	ME	-
56	ELECTRONIC TESTING & SUPERVISION	19	30	0.0	22,000	7	58	59	44	B	E	-
100	EQUIPMENT MONITORING & CONTROL	11	35	0.0	22,700	7	45	59	83	T	ME	-
119	Electrical Protection Technicians/ Technical Officers	12	30	0.0	23,500	4	55	58	77	A	E	269
175	Electrical Power Generation Supervisors	9	36	0.0	30,500	1 V	67	60	102	A	ME	270
207	Automatic Control System Technicians	5	31	0.0	22,300	5	20	60	78	B	E	271
183	Equipment Monitors & Maintainers*	6	37	0.0	23,000	5	67	57	87	A	ME	272
629	Microelectronic Design and Development Officers	9	34	0.0	24,100	3 V	78	66	213	A	E	273
562	Senior Microelectronic Maintenance Technicians	14	31	0.0	23,500	5	42	64	146	B	E	274
545	Senior Electronic Maintenance Officers	5	27	0.0	23,500	3 V	60	62	162	A	ME	275
308	Electronic Communication System Repair Officers	17	33	0.0	22,500	5	53	61	101	A	E	276
280	Electronic Control System Repair Technicians	8	26	0.0	20,900	4	25	56	134	T	ME	277
167	Senior Electronic Equipment Officers*	9	29	0.0	22,800	5	56	63	97	A	E	278
181	Electronic Technicians*	6	24	0.0	15,500	4	17	57	87	T	ME	279
315	Computer and Digital Equipment Installation Technicians	16	35	0.0	23,300	6	40	62	73	B	E	280
362	Computer and Digital Equipment Maintenance Technicians	6	28	0.0	22,500	3	50	55	46	T	E	281
216	Computer and Digital Control Technicians	10	25	10.0	20,100	5	40	56	58	T	E	282
229	Biotechnology and Other Instrument Technicians	5	32	0.0	21,100	4	60	55	36	B	E	283
179	Communication Systems Design and Assembly Technical Officers	5	32	0.0	19,300	4	100	55	50	B	E	284
206	Electronic Testers	6	27	0.0	19,900	3	83	56	42	B	G	285
92	Electronic Supervisors	10	32	0.0	22,300	5	50	63	45	B	E	286
16	EQUIPMENT ASSEMBLY & REPAIR	54	27	1.9	18,800	6	31	52	24	T	ME	-
215	Fluidic & Electronic Technicians	6	26	0.0	18,000	4	17	47	8	T	ME	287
86	Equipment Maintenance Technicians*	8	25	0.0	16,000	3 W	38	53	19	T	M	288

* 1. Cluster titles in capital letters indicate intermediate clusters, whereas cluster titles in lower-case letters indicate primary clusters. Cluster titles with an asterisk indicate the primary clusters that are regarded as marginal, having within group overlap indices of between 40% and 45%, or between groups overlap indices of between 25% and 30%.

2. States - Indicates the number of States or Territories represented in the cluster. Also indicated is the State or Territory representing over 40% of the members of intermediate clusters and over 50% of the members of primary clusters, where N = NSW, V = VIC, Q = Qld, S = SA, W = WA, T = TAS, A= ACT.

3. Education indicates the percentage of members of the cluster who have completed a certificate course in engineering or higher qualification.

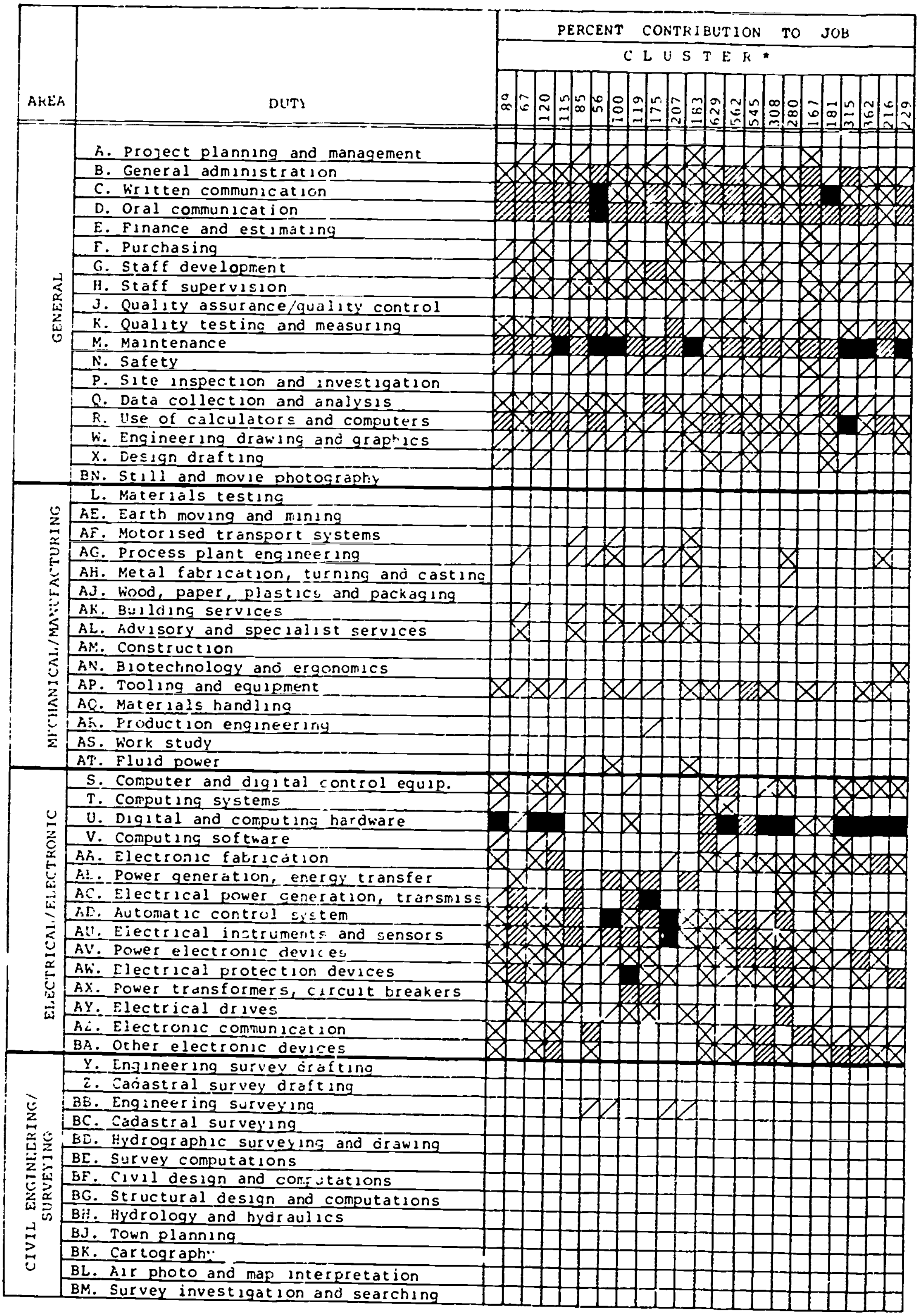
4. Task level index indicates the average level of tasks performed by members of the cluster. The minimum 0 indicates all tasks are performed by technician level workers or tradespersons. The maximum of 100 indicates that all tasks are performed by associate level workers or professional engineers. The actual range for all clusters is 47 to 72.

5. Level indicates the likely average level of the cluster, based on the variables of highest education, task level index, and number of tasks performed. A = associate level, T = technician level, B = blurred (probable mixture of both levels).

6. Area of specialisation indicates the main area(s) of specialisation of the cluster, where m = over 6% contribution from mechanical/manufacturing area, E = over 6% contribution from electrical/electronic area, C = over 6% contribution from civil engineering/surveying area. and G = general area, with less than 6% contribution in each of the other three areas.

7. Page number of job description indicates the page number in Appendix E of the task level job description (top 60 tasks only) of each cluster.

8. Average figures provide only an approximate indication of population characteristics, due to sampling error. Caution should be exercised in interpretation, particularly with primary cluster values, as most primary clusters comprise very small numbers of respondents.



NOTE: 1. The titles of each of these clusters are given in Table 6.7 and Figure 6.5.

2. □ = 0 to 1% contribution to job; ▨ = 5 to 10% contribution to job;
◸ = 1 to 2% contribution to job; ■ = over 10% contribution to job;
☒ = 2 to 5% contribution to job;

3. This figure includes adjacent heterogeneous clusters (see section 6.10)

Figure 6.20 Duty level job descriptions for clusters within and near electrical and electronic engineering

AREA	DUTY	179	206	92	37	39	40	58	30	16	19	26	57	215	63	86	36	51	41
		PERCENT CONTRIBUTION TO CLUSTER*																	
GENERAL	A. Project planning and management		/	/			/		X				/					X	X
	B. General administration		▨	■	▨	▨	▨		▨	X	X	/	▨		X		/	▨	■
	C. Written communication	▨	■	■	▨	▨	X	▨	▨	▨	■	X	■	▨	▨	/	X	▨	■
	D. Oral communication	▨	■	■	■	▨	X	▨	▨	■	■	▨	■	■	▨	■	▨	■	■
	E. Finance and estimating												/					▨	X
	F. Purchasing		/															▨	X
	G. Staff development		X	X	X	/	/	/	/	/	/	/	X		/	X	X	▨	X
	H. Staff supervision	/		▨	/		/	X	▨	X	X	X	▨		X	X		▨	X
	J. Quality assurance/quality control					/			▨									/	
	K. Quality testing and measuring	▨	■		X	X			■	X		X			X	▨	/	/	/
	M. Maintenance	▨	■	▨	▨	/		▨	X	■	X	■	X	▨	■	■	▨	▨	/
	N. Safety			/				X	X	/	X	/	X			/	/	X	/
	P. Site inspection and investigation					X			/										▨
	Q. Data collection and analysis	X	X	X	X	■	/	X	/	/		X				X			
	R. Use of calculators and computers	▨	X	▨	▨	■	■	▨	■	/	/	/	X		X		/	X	■
	W. Engineering drawing and graphics	X		X		X		X	/	/	X	/	X	/		X	/	X	/
	X. Design drafting	/											/		/	/	/		/
	BN. Still and movie photography												/						
MECHANICAL/MANUFACTURING	L. Materials testing		/						■							/			
	AE. Earth moving and mining																		
	AF. Motorised transport systems		/					/		X	/	X	X			▨		X	
	AG. Process plant engineering																X		
	AH. Metal fabrication, turning and casting							/		/	X	/				/		/	
	AJ. Wood, paper, plastics and packaging								/										
	AK. Building services					/											/	/	
	AL. Advisory and specialist services				/			/		/		/	/			X		X	
	AM. Construction																	X	
	AN. Biotechnology and ergonomics																		
	AP. Tooling and equipment				X				/	▨	▨	X	X	X	X	▨	X	/	X
	AQ. Materials handling										/			X				/	
	AR. Production engineering								/					/					
	AS. Work study																	/	
	AT. Fluid power									/	X	/		▨				/	
ELECTRICAL/ELECTRONIC	S. Computer and digital control equip.				X										/				
	T. Computing systems				X		/												
	U. Digital and computing hardware	▨	/	▨	■							/			X		/		
	V. Computing software					/													
	AA. Electronic fabrication	■			X					X	▨	/			X		▨		
	AB. Power generation, energy transfer							■		/		/	/		X		X	/	
	AC. Electrical power generation, transmiss.							■		/	/		X				X		
	AD. Automatic control system							X		X		X			X		X		
	AU. Electrical instruments and sensors	X		X	X	X		/		X		X	/		X	X	■	/	
	AV. Power electronic devices	▨		/	X					X		X			X		▨		
	AW. Electrical protection devices				/					X		/			X		■		
	AX. Power transformers, circuit breakers							▨		X	/			X			▨		
	AY. Electrical drives							/									X		
	AZ. Electronic communication	■		■						X		▨			▨		X		
	BA. Other electronic devices	▨	X	X	X					X		▨			▨			/	
CIVIL ENGINEERING/SURVEYING	Y. Engineering survey drafting						▨	/											
	Z. Cadastral survey drafting						▨												
	BB. Engineering surveying							/	X			/				X		/	X
	BC. Cadastral surveying						▨												
	BD. Hydrographic surveying and drawing																		
	BE. Survey computations						X												X
	BF. Civil design and computations								/										/
	BG. Structural design and computations																		
	BH. Hydrology and hydraulics					/													/
	BJ. Town planning																		
	BK. Cartography						■												
	BL. Air photo and map interpretation					X	■												
	BM. Survey investigation and searching						▨												

***NOTE:** 1. The titles of each of these clusters are given in Table 6.7 and Figure 6.5.

2. □ = 0 to 1% contribution to job; / = 1 to 2% contribution to job; X = 2 to 5% contribution to job; ▨ = 5 to 10% contribution to job; ■ = over 10% contribution to job;

3. This figure includes adjacent heterogeneous clusters (see section 6.10)

Figure 6.20 (continued)

- the proportion of females in each cluster ranges from 0% in a large number of clusters to a maximum of 10% in one cluster;
- the average salary ranges from $15,500 (cluster 181: electronic technicians) to $30,500 (cluster 175: electrical power generation supervisors);
- the percentage of members of the cluster completing an engineering certificate or higher qualification ranges from 17% in two clusters (cluster 181: electronic technicians; and cluster 215: fluidic and electronic technicians) to 100% (cluster 179: communication system design and assembly technical officers);
- the task level index ranges from 47 (cluster 215: fluidic and electronic technicians) to 66 (cluster 629: microelectronic design and development officers);
- the average number of tasks performed by each cluster ranges from 8 (cluster 215: fluidic and electronic technicians) to 213 (cluster 629: microelectronic design and development officers).

Table B-11 in Appendix B gives the percentage contribution of each of the four broad job functions areas for each cluster.

The duty level job descriptions in Figure 6.20 provide an overview of the duties providing high contributions to the work of each cluster, and clearly show the importance of duties in the electrical/electronic area for all of these clusters.

To obtain an accurate description of the job profile of each cluster, one needs to refer to the task level job descriptions in Appendix E.

6.10 HETEROGENEOUS CLUSTERS

A significant number of respondents formed clusters rather late in the hierarchical clustering process. Such clusters have relatively low within group overlap indices and between groups overlap indices. The members of these clusters tend to be heterogeneous in their job profiles. Though forming a 'loose' cluster, in their work patterns they behave more like individuals. Consequently the nature of the work of such clusters is usually difficult to interpret.

As mentioned in Section 3.5, Archer (1966) suggests minimum values of:

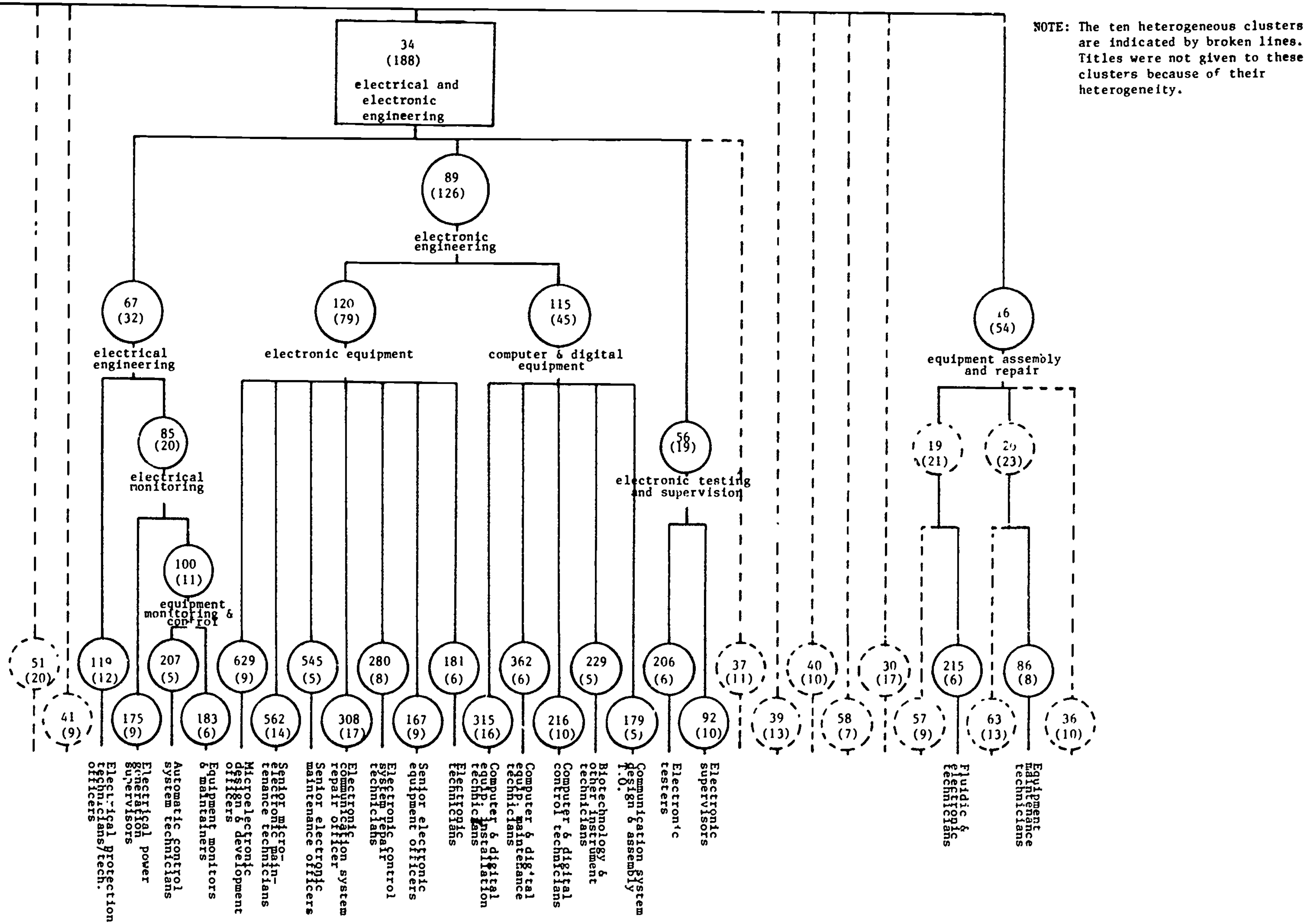


Figure 6.21 The heterogeneous clusters shown in Part 4 of the full cluster diagram

. 50% for within group overlap indices; and
. 35% for between groups overlap indices,

as an acceptable level for clusters representing distinct job types. In this study minimum values of 40% and 25% respectively were chosen because of the broad scope of the task inventory and the sample obtained. Clusters having indices above these values were reasonably easy to interpret.

Tere were ten outlying clusters not shown in the cluster diagram because they had within group overlap indices of less than 40% or between groups overlap indices of less than 25%, and thus were excluded from further analysis. Two of these rejected clusters were located between the major cluster of drafting and design and the major cluster of electrical and electronic engineering, and contained a total of 29 respondents. The other eight rejected clusters were located to the right of the major cluster of electrical and electronic engineering, and contained a total of 90 respondents. The ten rejected clusters are shown in Figure 6.21, which represents Part 4 of the full cluster diagram. Figure 6.21 also shows their position relative to the adjacent clusters.

The ten rejected clusters contained a total of 119 respondents. The underlying reason for their exclusion from further analysis is the heterogeneous nature of their job profiles resulting in a poor fit in any group or cluster. It is significant that most of these clusters were located in one area, and the number of respondents involved is also significant.

The duty level job descriptions of these clusters are given in Figure 6.20. Further data would need to be collected, probably by interviewing individual respondents, in order to draw conclusions on the nature of the work of these respondents and the relevance of present courses to their needs. It is suspected that TAFE and other education providers do not cater well for the education needs of these respondents because they do not form a single large and clearly definable group. The project resources did not allow a follow-up of these respondents.

<u>*Recommendation 1*</u>

That a study be undertaken of the section of the engineering technical workforce represented by the ten heterogeneous outlying clusters found in this study. The purpose of the study should be to determine the job functions and education and training needs of this section of the workforce.

CHAPTER 7: DISCUSSION OF THE GENERAL RESULTS

7.1 EDUCATION FOR THE RANGE OF ENGINEERING TECHNICAL WORKFORCE OCCUPATIONS

The primary clusters found in this study and discussed in the previous four sections represent the spectrum of occupational groups in the engineering technical workforce. It is suggested that TAFE and other providers of education and training for the engineering technical workforce should compare the needs, represented by these clusters (and presented in Chapter 6 and Appendix E), with their current overall provision of engineering courses. It is likely that suitable education programs are not available for all of these occupational groups in all States and Territories.

Differences in the types of industries and the way work is organised occur among the States and Territories, there being evidence for this in the distribution of the State/Territory variable among the primary clusters (see Tables 6.4, 6.5, 6.6 and 6.7). After allowing for this, there are likely to be gaps remaining in the scope of courses offered when compared with the educational needs of the engineering technical workforce.

<u>*Recommendation 2*</u>

That TAFE Authorities and other education and training providers use the results of this study to review their current courses for the engineering technical workforce. In particular, the needs of the engineering technical workforce, represented by the occupational clusters found in this study, should be compared with each Authority's overall provision of engineering courses.

Any thorough review of engineering courses should involve an examination of all of the occupational clusters found in this study, but some of the primary clusters warrant a particularly close examination because they show evidence of significant departures from the average distribution of educational qualifications. Of particular interest in this regard are the following responses to Question 9:

- blank response,
- completion of 'other course',
- certificate or associate diploma course commenced but not continued.

Clusters that show much higher than average rates for these three responses may indicate a gap in the provision of suitable TAFE or CAE courses for the particular needs of the occupational group represented by the cluster.

The whole sample distribution of 'highest education' responses for these three are:

- blank response - 55 respondents (4.5%),
- completion of other course - 34 respondents (2.9%),
- certificate or associate diploma course commenced but not continued - 67 respondents (5.7%),
- total of all three - 156 respondents (12.7%).

Primary clusters that showed a total of 25% (i.e. about double the whole sample rate) or more of these responses and 3 or more respondents giving these responses, are listed in Table 7.1.

TABLE 7.1 LIST OF PRIMARY CLUSTERS HAVING A HIGHER PROPORTION OF UNUSUAL EDUCATIONAL QUALIFICATIONS

CLUSTER NUMBERS	CLUSTER TITLE
609	Electronic Engineering Supervisors
357	Trade Supervisors
632	Materials Test Technicians/Officers
576	Electro-mechanical Engineering Officers
525	Hydrological Analysis Officers
261	Engineering Survey Assistants
338	Engineering Survey Drafters
562	Senior Micro-electronic Maintenance Technicians
315	Computer and Digital Equipment Installation Technicians
092	Electronic Supervisors

Recommendation 3

In reviewing their engineering courses, TAFE Authorities and other education and training providers should closely examine those occupational clusters in this study signalled as having a higher proportion of unusual educational qualifications.

7.2 COMMON DUTIES

For the purpose of vocational curriculum design and delivery there is much interest in identifying those duties that are common to two or more occupational groups, particularly in those areas where small student numbers are involved.

The duty level job descriptions of the major clusters (Figure 6.16) and the intermediate and primary clusters (Figures 6.17, 6.18, 6.19 and 6.20) provide a visual impression of the degree of commonality of each duty. It will be useful, however, to use a specific measure of degree of commonality.

The degree of commonality of each duty in the inventory of 61 duties was determined by using a simple benchmark. If the duty contributed over 2% to the job of the cluster overall, it was regarded as a sufficient contribution to warrant prima facie inclusion in any education or training program designed for the members of that cluster. In addition, if this threshold level of 2% contribution occurred in two or more clusters, it was regarded as a duty common to those clusters.

Using this benchmark, the degree of commonality of each duty among the 99 primary and 4 major clusters may be classified in one of six levels as follows:

- level 1 = duties common to all four major clusters
- level 2 = duty common to three major clusters
- level 3 = duty common to two major clusters
- level 4 = duty common in one major cluster
- level 5 = duty common to two or more primary clusters only
- level 6 = duty specialised in one primary cluster

Figure 7.1 illustrates the first four levels of commonality involving the four major clusters.

Applying the criteria for these six levels to the 61 duties in the inventory, the following results were obtained:

- 5 duties are at level 1
- 3 duties are at level 2
- 7 duties are at level 3
- 18 duties are at level 4
- 24 duties are at level 5
- 4 duties are at level 6.

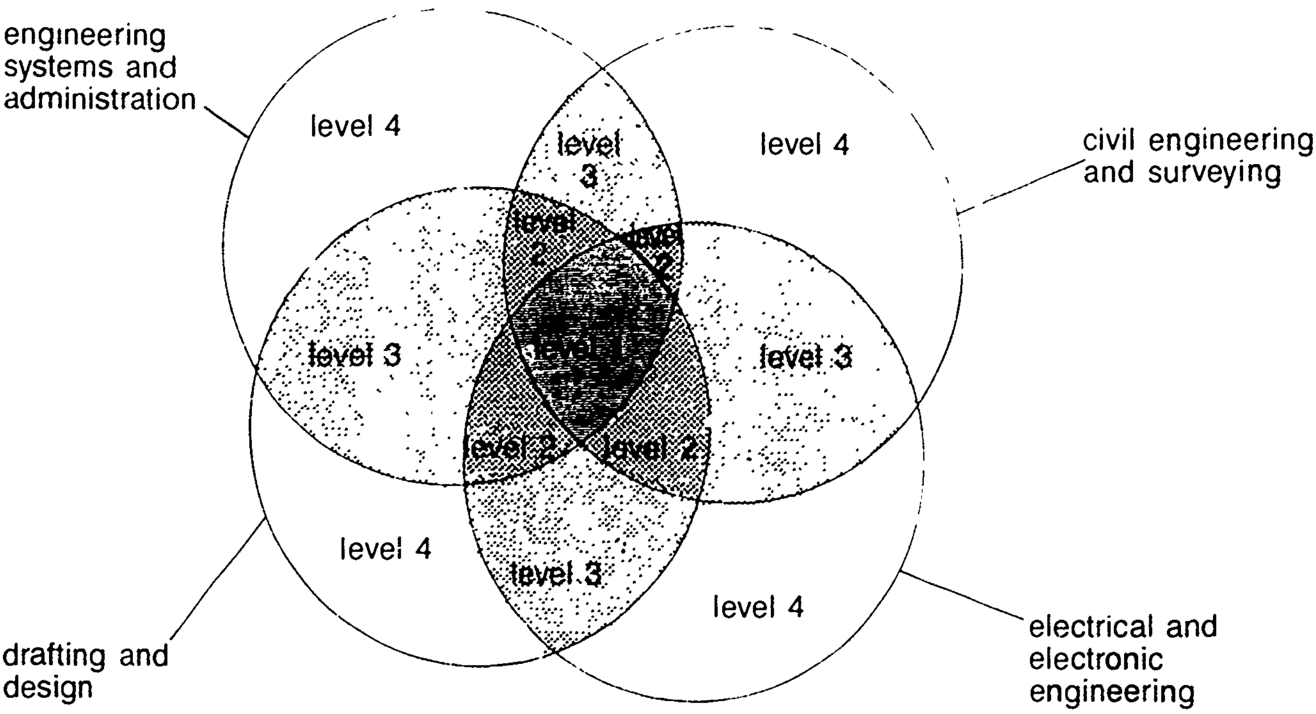


Figure 7.1 Venn diagram of duties in the four major clusters, showing four levels of commonality

Within each level, it is also possible to rank duties on the level of commonality by measuring the amount of overlap in percentage contribution to job. Thus all of the 61 duties have been arranged in hierarchical order based on degree of commonality. This hierarchical list is given in Table 7.2

When applying the information in Table 7.2 to the structure of new courses, some care should be taken if curriculum modules are designed to meet the needs of students in more than one branch of engineering. For example, data collection and analysis in civil engineering may require a somewhat different emphasis and different approach to data collection and analysis in electrical engineering. More detailed guidance is provided by the task level job descriptions in Appendix E. The common duties list in Table 7.2 provides only broad guidelines for the structure of engineering courses for the engineering technical workforce. Curriculum developers will need to refer to the more detailed task level information in Appendix E.

TABLE 7.2 HIERARCHICAL LIST OF DUTIES SHOWING THE DEGREE OF COMMONALITY

DUTY	MAJOR CLUSTERS IN WHICH DUTY IS MAINLY PERFORMED 74*	82*	68*	34*
1. DUTIES COMMON TO ALL FOUR MAJOR CLUSTERS:				
C. Written communication	x	x	x	x
D. Oral communication	x	x	x	x
B. General administration	x	x	x	x
R. Use of calculators and computers	x	x	x	x
H. Staff supervision	x	x	x	x
2. DUTIES COMMON TO THREE MAJOR CLUSTERS:				
W. Engineering drawing and graphics	x	x	x	
X. Design drafting	x	x	x	
G. Data collection and analysis	x	x		x
3. DUTIES COMMON TO TWO MAJOR CLUSTERS:				
M. Maintenance	x			x
E. Finance and estimating	x	x		
Y. Engineering survey drafting		x	x	
K. Quality testing and measuring	x			x
A. Project planning and management	x	x		
P. Site inspection and investigation	x	x		
G. Staff development	x			x
4. DUTIES COMMON IN ONE MAJOR CLUSTER:				
U. Digital and computing hardware				x
BB. Engineering surveying	x			
BE. Survey computations	x			
BF. Civil design and computations	x			
AU. Electrical instruments and sensors				x
F. Purchasing	x			
AV. Power electronic devices				x
BA. Other electronic devices				x
AD. Automatic control system				x
AA. Electronic fabrication				x
AW. Electrical protection devices				x
BL. Air photo and map interpretation		x		
AZ. Electronic communication				x
BH. Hydrology and hyraulics		x		
S. Computer and digital control equip.				x
AC. Electric. power generation,transmi.	x			
BG. Structural design and computations			x	
AH. Metal fabrication, turning and casting			x	
5. DUTIES COMMON TO TWO OR MORE PRIMARY CLUSTERS ONLY:				
J. Quality assurance, quality control	x			
AP. Tooling and equipment			x	
AM. Construction		x		
BK. Cartography		x		
N. Safety	x			
AL. Advisory and specialist services	x			
BM. Survey investigation and searching		x		
AK. Building services			x	
T. Computing systems				x
AB. Power generation, energy transfer				x
AT. Fluid power			x	
AX. Power transormers, circuit breakers				x
AY. Electrical drives				x
BC. Cadastral surveying		x		
V. Computing software				x
Z. Cadastral survey drafting		x		
AG. Process plant engineering				x
BN. Still and movie photography		x		
L. Materials testing	x			
AE. Earth moving and mining			x	
AF. Motorised transport systems	x			
AQ. Materials handling			x	
AS. Work study	x			
AR. Production engineering	x			
6. DUTIES SPECIALISED IN ONE PRIMARY CLUSTER:				
AJ. Wood, paper, plastics and packaging			x	
AN. Biotechnology and ergonomics				x
BD Hydrographic surveying and drawing		x		
BJ. Town planning		x		

NOTE: Cluster 74 = Engineering systems and administration
Cluster 82 = Civil engineering and surveying
Cluster 68 = Drafting and design
Cluster 34 = Electrical and electronic engineering

These results indicate that common or core curriculum units or modules could, subject to the above qualification, be developed for a range of occupational groups. The emergence of multi-discipline occupational clusters, as discussed in Section 7.3, should also provide an impetus to development of such curriculum units or modules. A further factor is the economic one. In areas where low student numbers are likely, common or core curriculum units provide a basis for obtaining larger classes.

Recommendation 4

That common or core curriculum modules be developed in those areas judged, on the basis of the results of this study and other information, to be sufficiently common to two or more engineering occupational groups.

7.3 LEVELS WITHIN THE ENGINEERING TECHNICAL WORKFORCE

While there is wide agreement in the literature on the existence of two levels within the engineering technical workforce, very little empirical evidence has been obtained to support this notion (see Section 3.2).

It is generally agreed that the educational qualifications required for associate level is completion of an engineering certificate or associate diploma. The education required for the technician level is less widely agreed, but is usually said to be either:

- completion of a trade course plus on-the-job training after completion of a trade;
- completion of a technician course;
- completion of a post-trade course specially designed for technician needs;
- partial completion of a certificate course and, possibly, on-the-job training.

Thus education provides a convenient method of dividing associate level from technician level, and many authors use the following benchmark:

- completion of an engineering certificate or equivalent qualification equals associate level;
- any 'lower' education qualification equals technician level or lower.

In this study evidence for the existence of two levels was sought by testing for any relationship between:

- educational qualification and perceived 'task level';
- educational qualification and range or number of tasks performed.

Educational qualification was reduced to the one simple statistic of whether each respondent had completed an engineering certificate or higher.

Perceived task level was measured by obtaining the average level rating of each task by a panel of experts who were familiar with associate level and technician level occupations. Details on how this was calculated are given in Section 4.3.

Number of tasks was measured by counting the number of tasks performed out of the inventory of 621 tasks.

The average values of these three variables were determined for each of the 99 primary clusters, and then correlation analysis was performed on the sample of 99 primary clusters.

A statistically significant correlation of 0.41 was found between average educational level and average task level of the clusters. Also a statistically significant correlation of 0.22 was found between average educational level and average number of tasks performed by the clusters. Scatter plots of these two relationships are given in Figures B-1 and B-2 in Appendix B.

The statistically significant correlation between average educational level and average task level of clusters confirms a relationship between educational level and occupational level. Occupational clusters that were perceived to be generally undertaking tasks at the higher of two levels tended to consist of members having higher educational qualifications (measured by the percentage completing an engineering certificate or higher). Occupational clusters that were perceived to be generally undertaking tasks at the lower of two levels tended to consist of members having lower education qualifications (completion of trade, trade technician, post-trade, part certificate, or other course).

Also the statistically significant correlation between average educational level and average number of tasks performed confirms a relationship between educational level and number and breadth of tasks performed. Occupational clusters that undertook a

large number of tasks tended to consist of members having a higher educational level. Occupational clusters that undertook a small number of tasks tended to consist of members having a lower educational level.

These results lend support to the notion of two, rather than one, occupational levels within the engineering technical workforce in Australia. The results also indicate the nature of these two levels, and agree with the key findings of other studies (as discussed in Sections 3.2 and 3.3) that:

- workers in occupations within the higher of the two levels generally undertake a broader range of tasks while workers in the lower of the two occupational levels generally undertake a narrower range of tasks;

- workers in occupations within the higher of the two levels generally have completed an engineering cerficate course or higher educational qualifications, while workers in the lower of the two occupational levels generally have completed other education and training, such as completion of a trade, trade technician, post-trade, part certificate or other course.

Table B-4 in Appendix B gives the distribution of highest engineering educational attainments for the whole sample. It is notable that of the 405 respondents who had technician level qualifications or lower, the largest group had partly completed, but were continuing, a certificate or associate diploma course, represented by 179 respondents (that is, 44% of the 405 technician level respondents). The second largest group was those that had partly completed, but not continued, a certificate or associate diploma course, represented by 67 respondents (17%). Relatively few had completed post-trade, trade or trade technician courses.

This situation is of concern to some writers, who suggest that partly completed certificate or associate diploma courses may not provide an appropriate education for engineering technician occupations, as these courses are primarily designed around the needs of engineering associate occupations (see Section 3.3). This issue is likely to increase in significance in the future, as many writers have predicted an increase in the numbers employed in engineering technician occupations (see Section 3.4).

Recommendation 5

That TAFE Authorities and other education and training providers recognise the existence of two engineering occupational levels between trade and professional level, and that these be termed:

- *engineering technician level,*
- *engineering associate level.*

Further, that education and training programs be provided for occupational groups within each level, appropriate to their particular needs.

Despite these findings, other results in the study indicate there is 'blurring' of boundaries between occupational levels. For example, each of the 99 occupational clusters identified in this study consisted of engineering technical workers performing quite similar tasks, yet most of the clusters consisted of members having varying educational qualifications (see Tables 6.4, 6.5, 6.6, and 6.7). On the other hand when the sample is divided into two groups by education, namely:

- those having associate level qualifications or higher,
- those having technician level qualifications or lower

members of both levels often appear in the same occupational cluster and perform similar tasks.

To identify the clusters that showed evidence of blurring across the technician-associate boundary, a simple algorithm was designed to combine the three variables of:

- highest education (percentage completing certificate),
- task level index,
- number of tasks,

and then categorise the <u>average</u> level of each primary cluster as either associate, blurred, or technician.

Highest education is regarded by most authors as the critical variable in determining engineering occupational level (see Section 3.3), so the algorithm is based on the assumption that 66% of the whole sample are employed in associate level occupations and 34% are employed in technician level occupations, as 66% of the whole sample have completed a certificate course in engineering or higher. The three

pertinent variables were then dichotomised using the 34th percentile of each variable as follows:

- highest education - over 50% of cluster = high, equal or under 50% of cluster = low;
- task level index - over 59 = high, equal or under 59 = low;
- number of tasks - over 50 = high, equal or under 50 = low.

Using these three dichotomised variables, the three categories of average level of cluster were determined using the algorithm in Table B-7 in Appendix B. It is important to note that this algorithm gives more weight to the education variable than the other two variables.

TABLE 7.3 FREQUENCY CROSS-TABULATION OF THE 99 PRIMARY CLUSTERS, AT EACH LEVEL BY MEMBERSHIP OF MAJOR CLUSTER

	AVERAGE LEVEL			
MAJOR CLUSTER OF MEMBERSHIP	associate	blurred	technician	TOTAL
Engineering systems and administration	38	4	2	44
Civil engineering/surveying	18	2	1	21
Drafting & design	3	7	3	13
Electrical & electronic engineering	7	7	4	18
Outliers	1	-	2	3
TOTAL:	67	20	12	99

The average level of each cluster is given in Tables 6.4, 6.5, 6.6 and 6.7 in the third last column. A summary of these results for the 99 primary clusters is given in Table 7.3. The table indicates that as many as 20 of the 99 primary clusters appeared to be blurred across the technician-associate boundary.

This type of blurring mostly occurs in the major cluster drafting and design and the major cluster electrical and electronic engineering.

This blurring appears to occur at all boundaries between occupational levels in engineering, though the associate-professional boundary and the technician-grade boundary were not closely examined in this study. For example, a small number of respondents (1.7%) indicated they had completed a university degree in engineering, yet classed themselves as a member of the engineering technical workforce by answering 'yes' to the first question.

The blurring across the technician-associate boundary indicates that members of these occupational clusters may require a combination of associate level and technical level education, where separate educational programs are offered for each level.

Recommendation 6

In cases where separate educational programs are designed for each of the two engineering technical workforce levels, that appropriate combinations of both programs be available for those within occupational clusters requiring skills across both levels.

7.4. MULTI-DISCIPLINE CLUSTERS

It is apparent from the duty level and task level job descriptions that a significant number of primary clusters undertake many duties and tasks in more than one of the following three specialised engineering areas:

- mechanical/manufacturing;
- electrical/electronic;
- civil engineering/surveying.

Such clusters are termed multi-discipline clusters in this study, but other terms such as multi-skilling are used in the literature for individuals or occupational clusters whose work involves tasks, to a significant extent, in more than one discipline or area as listed above. In Figure 1.2 on page 5 'cluster B' provides a simple illustration of a multi-discipline cluster.

Some writers have suggested that there is a trend in Australia and elsewhere towards an increase in this type of work, and suggest that a major influence is the introduction of new technology. The trend towards multi-discipline clusters is sometimes referred to as 'blurring' (Ford, 1986).

In this study it was decided to have a closer look at such clusters, and the following criterion was used to define (and thus identify) such multi-discipline clusters for the purpose of this closer study:

> multi-discipline clusters are those that have an average percentage contribution over the whole cluster of more than 6% in more than one specialised area as specified in this study.

The value of 6% was chosen because it was significantly above the average percentage contribution in the <u>second</u> ranking specialised area of the primary cluster.

TABLE 7.4 LIST OF MULTI-DISCIPLINE CLUSTERS

CLUSTER NUMBER	CLUSTER TITLE	SPECIALISED AREAS CONTRIBUTING TO JOB OF CLUSTER*		
		Mechanical/ Manufacturing	Electrical/ Electroni	Civil Eng./ surveying
240	Planners of new electricity supply		**	*
671	Electrical engineering estimators		**	*
305	Building services designers	**	*	
664	Mechanical design drafters	**		*
657	Design drafters (computerised)	**		*
299	Senior hydrology technical officers	*	**	**
609	Electronic engineering supervisors	*	*	
277	Senior production and engineering quality controllers	**		*
349	General test technicians/officers	**	**	
135	Cartographic survey supervisors	*		*
526	Senior electric supply controllers	**	**	
548	Electric supply controllers	*	**	
76	Electro-mechanical engineering officers	**	**	
234	Electro-mechanical control system designers	**	**	
259	Production engineering officers	*	*	
763	Civil engineering site supervisors	*		**
704	Civil engineering site officers	*		**
246	Survey computation officers		*	**
445	Structural designers and drafters	**		**
471	Civil and structural designers and drafters	**		**
126	Senior structural analysis and design officers	**		**
392	Structural design drafters	*		*
285	Mechanical designers	*		*
175	Electrical power generation supervisors	**	**	
183	Equipment monitors and maintainers	**	**	
545	Senior electronic maintenance technicians	*	**	
280	Electronic control system repair technicians	*	**	
181	Electronic technicians	*	**	
215	Fluidic and electronic technicians	**	*	

*NOTE: * indicates 6 to 10% contribution to job over the whole cluster
** indicates more than 10% contribution to job over the whole cluster

Using the 6% criterion, 29 of the 99 primary clusters were found to be multi-discipline clusters, and these are listed in Table 7.4. If a stricter 10% criterion is used, eight of the 29 clusters remain. These eight may be regarded as strongly multi-disciplinary. They are:

- cluster 299 - senior hydrology technical officers
- cluster 576 - electro-mechanical engineering officers
- cluster 234 - electro-mechanical control system designers
- cluster 445 - structural designers and drafters
- cluster 471 - civil & structural analysis & design officers
- cluster 126 - senior structural analysis & design officers
- cluster 175 - electrical power generation supervisors
- cluster 183 - equipment monitors & maintainers.

Table 7.4 indicates that the most common combination of areas is mechanical/manufacturing with electrical/electronic, this combination occurring for 14 clusters. The mechanical/manufacturing with civil engineering/surveying combination occurred for 11 clusters. The electrical/electronic with civil engineering/surveying occurred for 3 clusters. Only one cluster (cluster 299: senior hydrology technical officers) involved a significant combination of tasks in all three areas.

Another feature is the fact that these clusters tend to be concentrated in just one of the four major clusters, this being the engineering systems and administration cluster. Of the 29 multi-discipline clusters, 19 were located in the major cluster of engineering systems and administration.

The existence of these clusters and the likely trend towards an increase in 'blurring' across discipline boundaries, (see Section 3.4), have important implications for the design of engineering technician and associate level courses. At present courses are generally structured within one major area. Students requiring skills in a combination of areas may be required to complete a course in one area only and take additional subjects in another area.

Two types of course could be designed to meet the needs of such students. One type would be a course that is specially designed to meet the needs of a particular multi-discipline cluster. Another type would be a course made up of curriculum modules from existing courses in two or more areas. The second type assumes that the existing 'one-discipline' courses already have a modular structure.

The second solution appears to be the most practical because it provides the maximum flexibility. A variety of multi-discipline clusters, as well as one-discipline clusters, could be catered for by different combinations of modules.

Three types of curriculum module could be designed to meet these needs:

- common or core curriculum modules for those duties or areas that are common across a large number of clusters (see Section 7.2). Completion of these modules would be compulsory in any complete program;

- specialised curriculum modules designed for single-discipline clusters. Such modules could be elective, though some restrictions on which module combinations are allowed could be applied;

- specialised curriculum modules designed for multi-discipline clusters.

Each student could choose the combination of modules to suit his/her vocational education needs. Programs for students undertaking multi-discipline work would comprise all three of the above types of curriculum module.

Recommendation 7

That educational programs designed for the engineering technical workforce be designed in a modular system to allow appropriate choice of modules for:

- *mono-discipline, or*
- *multi-discipline*

occupations. Such programs should comprise appropriate combinations of:

- *common or core curriculim modules;*
- *specialised curriculum modules designed for single-discipline clusters;*
- *specialised curriculum modules designed for multi-discipline clusters.*

Using a similar criterion of 'more than 6% contribution from the area of specialisation', the remaining 70 mono-discipline primary clusters may be placed into one of four categories as follows:

- M = over 6% contribution from the mechanical/manufacturing area;
- E = over 6% contribution from the electrical/electronic area;
- C = over 6% contribution from the civil engineering/ surveying area;
- G = high general area contribution, with less than 6% contribution in each of the three specialised areas.

Applying this method of classification, the 70 mono-discipline clusters were distributed as follows:

AREA	NUMBER OF CLUSTERS
Mechanical/manufacturing	16
Electrical/electronic	18
Civil eng./surveying	25
General	11
TOTAL:	70

Using the variable of area of specialisation for the horizontal axis and the variable of average cluster level for the vertical axis, it is possible to place primary clusters in a two

TABLE 7.5 CROSS TABULATION OF THE 99 PRIMARY CLUSTERS BY LEVEL AND MAIN AREA OF SPECIALISATION

LEVEL (average cluster level)	MAIN AREA(S) OF SPECIALISATION								TOTAL
	General G	Mechanical/ Manufacturing M	Electrical/ Electronic E	Civil eng./ Surveying C	M+E	E+C	M+C	M+E+C	
Associate	6	11	8	18	11	2	10	1	67
Blurred	3	2	8	5	0	1	1	0	20
Technician	2	3	2	2	3	0	0	0	12
TOTAL	11	16	18	25	14	3	11	1	99

dimensional space. However some of the multi-discipline clusters are difficult to place in a two-dimensional space as they cross more then one boundary between engineering disciplines. A simple version of such a two-dimensional space is given in Figure 1.2 in Chapter 1. Table 7.5 shows the 99 primary clusters cross-tabulated by area of specialisation and average cluster level. This table indicates that there is vertical blurring across all three areas of specialisation, though it is most frequent in the electrical/electronic area. Also there is horizontal blurring for all three cluster levels. Two primary clusters exhibited both horizontal and vertical blurring.

7.5 FUTURE TRENDS

A number of writers (see Chapter 3) have referred to one or both of the following trends in engineering occupations:

- an increase in the degree of 'blurring', with more occupations requiring skills across two or more engineering disciplines;

- an increase in the numbers required in technician level occupations.

Often is it argued that such changes are caused, at least partly, by technological changes in industry.

This study has provided some evidence for:

- the existence of 'blurred' occupational clusters within the engineering technical workforce;
- the existence of technician level occupational clusters in all major disciplines of the engineering technical workforce.

If these trends continue, the results of this study and similar studies will steadily become out-of-date and therefore less useful to TAFE and other education and training providers.

To address this problem, it is suggested that a study or studies be undertaken of present and near future trends (that is, the period from 1986 to about 1991), in engineering technical workforce occupations. The study could look at all engineering disciplines as in this study, or a number of separate studies could be undertaken of each major engineering discipline. These

studies could employ Dephi methodology. They should use the results of this study as a starting point.

In addition, a future major study around the year 1990 could be conducted of all engineering technical workforce occupations. The study should employ a methodology similar to the present study, and use the task inventory from the present study. Such a study would provide valuable comparisons with the results of the present study and thus indicate possible longer-term trends.

<u>*Recommendation 8*</u>

That a study undertaken of present and near future trends in engineering technical workforce occupations, using the results of the present study as a starting point.

That, in addition, a future major study be undertaken of engineering technical workforce occupations around the year 1990, the study using the task inventory from the present study.

1:0

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APPENDIX A: FURTHER TABLES FROM THE LITERATURE

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TABLE A-1 CROSS-TABULATION OF EMPLOYEES BY ENGINEERING TECHNICAL WORKFORCE OCCUPATION AND BY STATE/TERRITORY, FROM THE 1981 CENSUS

STATE	DRAFTSMEN 7 TRACERS	CIVIL ENG. TECHN.	ELECTRICAL/ ELECTRONIC T.	MECHANICAL ENG. TECHN.	MINING TECHN.	ENG. TECHN. NEC.	TOTAL	% OF ALL ENG. TECHN.
N.S.W.	11602	2788	6364	1542	282	2304	24882	36.5
VIC.	8435	2051	5081	1291	25	2038	18921	27.8
QLD.	4706	1171	1783	205	128	522	8515	12.5
S.A.	2728	732	1370	469	49	622	5970	8.8
W.A.	3872	818	696	167	113	402	6068	8.9
TAS.	807	191	309	53	36	170	1566	2.3
A.C.T.	729	224	340	75	7	114	1489	2.2
N.T.	337	98	175	17	12	41	680	1.0
TOTAL:	33218	8071	16118	3819	653	6213	68092	100.0

SOURCE: AUSTRALIAN BUREAU OF STATISTICS (1983). 1981 CENSUS OF POPULATION AND HOUSING, TABLE 74.

NOTE:
1. Each cell in this table has been slightly randomly adjusted by ABS to avoid the release of confidential data. Totals may be slightly more or less than the sum of their components.
2. Component percentages may total slightly more or less than 100 because of rounding of component percentages.

TABLE A-2 CROSS-TABULATION OF EMPLOYEES BY ENGINEERING TECHNICAL WORKFORCE OCCUPATION AND BY INDUSTRY, FROM THE 1981 CENSUS

	DRAFTSMEN & TRACERS	CIVIL ENG. TECHN.	ELECTRICAL/ ELECTRONIC T.	MECHANICAL ENG. TECHN.	MINING TECHN.	ENG. TECHN. NEC.	TOTALS	% OF ALL ENG. TECHN.
A. Agriculture, forestry, fishing, hunting	178	27	3	3	1	8	220	0.3
B. Mining	884	197	39	41	465	231	1857	2.7
C. Manufacturing	6360	237	1682	1993	58	2876	13206	19.4
D. Electricity, gas, water	3670	800	2543	158	-	384	7555	11.1
E. Construction	2991	1630	241	84	7	188	5141	7.6
F. Wholesale or retail trade (including installation and repair of equipment)	660	71	344	110	14	278	1477	2.2
G. Transport or storage	688	240	808	355	3	319	2413	3.5
H. Communication	1416	172	7963	39	-	153	9743	14.0
I. Public accountant, finance, property and business services	10949	2668	201	200	36	245	14299	21.0
J1. Public administration	3879	1613	378	190	17	475	6552	9.6
J2. Defence	461	45	611	313	2	466	1898	2.8
K. Community services (including health, education and research services)	440	271	933	284	50	462	2440	3.6
L. Recreation, personal and other services (including sport and entertainment)	117	23	289	7	2	44	482	0.7
M1. Non-classifiable	369	55	64	36	-	55	579	0.9
M2. Industry not stated	156	27	27	6	3	25	244	0.4
TOTALS:	33218	8071	16118	3819	653	6213	68092	100.0

SOURCE: AUSTRALIAN BUREAU OF STATISTICS (1983). 1981 CENSUS OF POPULATION AND HOUSING, TABLE 74.

NOTE: 1. Each cell in this table has been slightly randomly adjusted by ABS to avoid the release of confidential data. Totals may be slightly more or less than the sum of their components.
2. Component percentages may total slightly more or less than 100 because of rounding of component percentages.

APPENDIX B: FURTHER TABLES OF RESULTS

TABLE B-1 FREQUENCY CROSS-TABULATION OF JOB TITLES BY FIELDS OF ENGINEERING FOR THE SAMPLE

FIELD OF ENGINEERING	Tradesman/ tradesperson	Technical assistant	Engineering assistant	Technical officer	Detail draftsman/ person	Trainee draftsman/ person	Design draftsman/ person	Trainee technician	Technician	Foreman/foreperson	Supervisor	Professional engineer	Others	Total
Electronic engineering	9 (5)	7 (4%)	4 (2%)	80 (44%)	1 (1%)	1 (1%)	2 (1%)	7 (4%)	45 (25%)	1 (1%)	13 (7%)	0 (0%)	12 (7%)	182 (100%)
Electrical engineering	20 (13%)	4 (3%)	7 (5%)	53 (34%)	4 (3%)	3 (2%)	18 (12%)	4 (3%)	5 (3%)	2 (1%)	18 (11%)	5 (3%)	12 (8%)	155 (100%)
Mechanical engineering	25 (12%)	4 (2%)	7 (3%)	40 (20%)	9 (4%)	5 (2%)	50 (25%)	2 (1%)	4 (2%)	11 (5%)	16 (8%)	10 (5%)	21 (10%)	204 (100%)
Production engineering	1 (4%)	1 (4%)	1 (4%)	4 (17%)	1 (4%)	0 (0%)	0 (0%)	0 (0%)	2 (9%)	1 (4%)	4 (17%)	3 (13%)	5 (22%)	23 (100%)
Work study mechanical engineering	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (50%)	1 (50%)	2 (100%)
Structural engineering	2 (3%)	1 (1%)	5 (6%)	2 (3%)	16 (21%)	5 (6%)	27 (35%)	0 (0%)	0 (0%)	0 (0%)	8 (10%)	7 (9%)	4 (5%)	77 (100%)
Materials testing	0 (0%)	2 (6%)	0 (0%)	16 (50%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	6 (6%)	0 (0%)	4 (4%)	0 (0%)	4 (12%)	32 (100%)
Civil engineering	0 (0%)	4 (2%)	52 (19%)	64 (24%)	14 (5%)	6 (2%)	62 (23%)	3 (1%)	12 (5%)	2 (1%)	25 (9%)	12 (5%)	9 (3%)	265 (100%)
Hydraulogy	0 (0%)	3 (20%)	0 (0%)	10 (67%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (7%)	1 (7%)	15 (100%)
Surveying	0 (0%)	1 (1%)	7 (9%)	26 (32%)	10 (12%)	5 (6%)	3 (4%)	2 (2%)	6 (7%)	1 (1%)	5 (6%)	1 (1%)	15 (18%)	82 (100%)
Mining engineering	0 (0%)	1 (10%)	1 (10%)	0 (0%)	0 (0%)	0 (0%)	4 (40%)	0 (0%)	0 (0%)	1 (10%)	1 (10%)	0 (0%)	2 (20%)	10 (100%)
Automotive engineering	14 (47%)	0 (0%)	0 (0%)	4 (13%)	2 (7%)	0 (0%)	0 (0%)	0 (0%)	2 (7%)	2 (7%)	3 (10%)	1 (3%)	2 (7%)	30 (100%)
Marine engineering	0 (0%)	0 (0%)	0 (0%)	2 (22%)	0 (0%)	1 (11%)	1 (11%)	0 (0%)	1 (11%)	1 (11%)	2 (22%)	1 (11%)	0 (0%)	9 (100%)
Aeronautical engineering	3 (14%)	2 (190%)	0 (0%)	7 (33%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (14%)	0 (0%)	6 (29%)	21 (100%)
Whole sample	82 (7%)	38 (3%)	87 (7%)	334 (27%)	61 (5%)	29 (2%)	175 (14%)	18 (1%)	88 (7%)	27 (2%)	112 (9%)	48 (4%)	118 (10%)	1217 (100%)

<u>**NOTES:**</u>
1. There were 1217 non-blank responses and 13 blank responses to Question 4.
2. The percentages shown are <u>row</u> percentages.

TABLE B-2 FREQUENCY CROSS-TABULATION OF ALL ENGINEERING EDUCATIONAL ATTAINMENTS BY TYPE OF COURSE AND TYPE OF ATTAINMENT

	TYPE OF ATTAINMENT			
TYPE OF COURSE	Currently in progress	Commenced but not continued	Completed	TOTAL
trade technical or technician course at technical college	15	14	322	351 (19%)
post-trade course at techanical college	13	24	98	135 (7%)
certificate course at technical college	133	52	469	654 (35%)
post or higher certificate course at technical college	6	15	58	79 (4%)
associate diploma course technical college	11	13	37	61% (3%)
certificate course at college of advanced educ.	39	8	100	147 (8%)
associate diploma course at college of advanced educ. or institute of technology	45	22	67	134 (7%)
degree or diploma course at college of advanced educ. or institute of technology	32	59	37	128 (7%)
degree course at university	9	32	20	61 (3%)
Other course	10	5	83	98 (5%)
TOTAL:	313 (17%)	244 (13%)	1291 (70%)	1848 (100%)

NOTES:
1. As multiple responses were allowed n = 1848 is larger than the sample size of 1230
2. Of the 1230 respondents, 55 gave no response, 500 gave one response, 354 gave two responses, and 160 gave three or more responses to Question 9 on engineering educational attainments.

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TABLE B-3 FREQUENCY CROSS-TABULATION OF MOST RECENT ENGINEERING EDUCATION ATTAINMENT BY TYPE OF COURSE AND TYPE OF ATTAINMENT

	TYPE OF ATTAINMENT			
TYPE OF COURSE	Currently in progress	Commenced but not continued	Completed	TOTAL
trade technical or technician course at technical college	10	9	71	90 (8%)
post-trade course at technical college	7	14	38	59 (5%)
certificate course at technical college	89	36	340	465 (43%)
post or higher certificate course at technical college	4	7	43	54 (5%)
associate diploma course technical college	8	8	29	45 (4%)
certificate course at college of advanced educ.	26	5	78	109 (10%)
associate diploma course at college of advanced educ. or institute of technology	28	14	53	91 (8%)
degree or diploma course at college of advanced educ. or institute of technology	14	27	27	68 (6%)
degree course at university	7	8	11	26 (2%)
other course	5	3	54	62 (6%)
TOTAL:	198 (18%)	131 (12%)	744 (69%)	1073 (100%)

NOTES:

1. Responses were counted if <u>both</u> the attainment and the last year of study were indicated.
2. Of the sample of 1230 respondents, 157 left either the attainment or the last year of study (or both) blank. There were 1073 complete responses.

TABLE B-4 FREQUENCY DISTRIBUTION OF WHOLE SAMPLE ON HIGHEST EDUCATION HIERARCHY

'HIGHEST EDUCATION' HIERARCHY	NEW HIERARCHICAL CODE	OLD CODES (Question 9)	FREQUENCY
part "other" (currently in progress)	A	28	1
part "other" (commenced but not continued)	B	29	1
complete "other	C	30	34
part trade (currently in progress)	D	01	6
part trade (commenced but not continued)	E	02	7
complete trade	F	03	56
part post-trade (currently in p_ogress)	G	04	7
part post-trade (commenced but not continued)	H	05	11
complete post-trade	I	06	36
part certificate/associate diploma (currently in progress)	J	07 13 16 19	179
part certificate/associate diploma (commenced but not continued)	K	08 14 17 20	67
complete certificate/associat diploma	L	09 15 18 21	517
part post/higher certificate (currently in progress)	M	10	6
part post/higher certificate (commenced but not continued)	N	11	13
complete post/higher certificate	O	12	48
part degree/diploma (currently in progress)	P	22 25	39
part degree/diploma (commenced but not continued)	Q	23 26	90
complete degree/diploma	R	24 27	57
lower than complete certifi cate (A to K)	X		405
complete certificate or higher (L to R)	Y		770
TOTAL:			1175

NOTE: Of the sample of 1230 respondents there were 55 blank and 1175 non-blank responses to Question 9 on engineering educational attainments.

TABLE B-5 FREQUENCY CROSS-TABULATION OF THE WHOLE SAMPLE BY INDUSTRY CATEGORY AND FIELD OF ENGINEERING OF THE RESPONDENT

FIELD OF ENGINEERING	Agriculture, forestry, fishing, hunting	Mining	Manufacturing	Electricity, gas, water	Construction	Wholesale or retail trade	Transport or storage	Communication	Public accountant, finance, property, and business services	Public administration	Defence	Community services (including health education and research services)	Recreation, personal and other services (including sport and entertainment)	General consulting engineering (covering two or more of the above areas)	Non-classifiable (please specify)	Whole sample
Electronic engineering	0 (0%)	5 (3%)	4 (2%)	20 (11%)	4 (2%)	19 (10%)	9 (5%)	53 (29%)	0 (0%)	2 (1%)	37 (20%)	8 (4%)	1 (1%)	1 (1%)	21 (11%)	184 (15%)
Electrical engineering	0 (0%)	4 (3%)	16 (10%)	64 (41%)	19 (12%)	5 (3%)	12 (8%)	6 (4%)	0 (0%)	2 (1%)	5 (3%)	1 (1%)	0 (0%)	12 (8%)	10 (6%)	156 (13%)
Mechanical engineering	8 (4%)	7 (4%)	45 (23%)	32 (16%)	17 (9%)	6 (3%)	8 (4%)	3 (2%)	0 (0%)	2 (1%)	19 (10%)	6 (3%)	0 (0%)	22 (11%)	25 (13%)	200 (16%)
Production engineering	2 (9%)	2 (9%)	10 (43%)	2 (9%)	0 (0%)	0 (0%)	1 (4%)	1 (4%)	0 (0%)	0 (0%)	3 (13%)	0 (0%)	0 (0%)	0 (0%)	2 (9%)	23 (2%)
Work study mechanical engineering	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (50%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (50%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (0%)
Structural engineering	1 (1%)	0 (0%)	4 (5%)	0 (0%)	37 (48%)	1 (1%)	2 (2%)	2 (3%)	0 (0%)	1 (1%)	2 (3%)	2 (3%)	0 (0%)	23 (30%)	2 (3%)	77 (6%)
Materials testing	0 (0%)	0 (0%)	0 (0%)	4 (13%)	17 (53%)	0 (0%)	2 (6%)	0 (0%)	0 (0%)	0 (0%)	1 (3%)	1 (3%)	0 (0%)	3 (9%)	4 (13%)	32 (3%)
Civil engineering	2 (1%)	2 (1%)	0 (0%)	34 (12%)	80 (30%)	0 (0%)	11 (4%)	0 (0%)	0 (0%)	32 (12%)	0 (0%)	18 (7%)	[illegible] (0%)	3 (14%)	47 (18%)	264 (22%)
Hydraulogy	0 (0%)	0 (0%)	0 (0%)	5 (33%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (27%)	0 (0%)	0 (0%)	6 (40%)	15 (1%)
Surveying	0 (0%)	6 (7%)	0 (0%)	10 (12%)	18 (22%)	0 (0%)	1 (1%)	0 (0%)	1 (1%)	7 (9%)	0 (0%)	2 (2%)	0 (0%)	6 (7%)	30 (37%)	81 (7%)
Mining engineering	0 (0%)	8 (80%)	0 (0%)	1 (10%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (10%)	0 (0%)	10 (1%)
Automotive engineering	2 (7%)	2 (7%)	8 (27%)	2 (7%)	0 (0%)	2 (7%)	2 (7%)	0 (0%)	0 (0%)	1 (3%)	3 (10%)	2 (7%)	0 (0%)	0 (0%)	6 (20%)	30 (2%)
Marine engineering	0 (0%)	0 (0%)	1 (11%)	1 (11%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (11%)	2 (22%)	0 (0%)	0 (0%)	1 (11%)	3 (33%)	9 (1%)
Aeronautical engineering	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (5%)	7 (33%)	0 (0%)	0 (0%)	2 (10%)	5 (24%)	1 (5%)	0 (0%)	0 (0%)	5 (24%)	21 (2%)
Whole sample	22 (2%)	38 (3%)	90 (8%)	197 (16%)	203 (17%)	37 (3%)	59 (5%)	73 (6%)	1 (0%)	54 (4%)	88 (7%)	51 (4%)	2 (0%)	115 (9%)	180 (15%)	1216 (100%)

NOTES 1. For the sample of 1230 respondents, there were 1216 non-blank responses and 14 blank responses to Question 13.

2. The percentages shown on row percentages.

TABLE B-6 FREQUENCY DISTRIBUTION OF HIGHEST EDUCATION HIERARCHY FOR THE FOUR MAJOR CLUSTERS

'HIGHEST EDUCATION' HIERARCHY	NEW HIERARCHICAL CODE	MAJOR CLUSTER: 74 Engineering systems and administrative	82 Civil engineering and surveying	68 drafting and design	34 electrical and electronic engineering
part "other" (currently in progress)	A	0 0%	0 0%	0 0%	1 .60%
part "other" (commenced but not continued)	B	0 0%	1 .3%	0 0%	0 0%
complete "other"	C	19 4.6%	6 2.0%	0 0%	7 3.8%
part trade (currently in progress)	D	1 .20%	0 0%	0 0%	2 1.10%
part trade (commenced but not continued)	E	1 .20%	2 .70%	0 0%	2 1.10%
complete trade	F	29 7.0%	1 .30%	3 2.50%	11 6.00%
part post-trade (currently in progress)	G	1 .20%	0 0%	0 0%	2 1.10%
part post-trade (commenced but not continued)	H	4 1.0%	0 0%	2 1.70%	3 1.60%
complete post-trade	I	20 4.80%	0 0%	1 .80%	6 3.30%
part certificate/associate diploma (currently in progress)	J	38 9.20%	32 10.50%	22 18.20%	44 24.00%
part certificate/associate diploma (commenced but not continued)	K	21 5.10%	16 5.20%	8 6.60%	14 7.70%
complete certificate/associate diploma	L	172 41.70%	163 53.30%	67 55.40%	61 33.30%
part post/higher certificate (currently in progress)	M	1 .20%	2 .70%	2 1.70%	1 .60%
part post/higher certificate (commenced but not continued)	N	7 1.70%	3 1.0%	2 1.70%	1 .60%
complete post/higher certificate	O	28 6.80%	5 1.60%	2 1.70%	10 5.50%
part degree/diploma (currently in progress)	P	14 3.40%	18 5.90%	4 3.30%	2 1.10%
part degree/diploma (commenced but not continued)	Q	25 6.10%	38 12.40%	8 6.60%	14 7.70%
complete degree/diploma	R	32 7.80%	19 6.20%	0 0%	2 1.10%
lower than complete certificate (A to K)	X	134 (32%)	58 (19%)	36 (30%)	92 (50%)
complete certificate or higher (L to R)	Y	279 (68%)	248 (81%)	85 (70%)	91 (50%)
TOTAL:		413 (100%)	306 (100%)	121 (100%)	183 (100%)

NOTE: For cluster 74 there were 25 blank responses, for cluster 82 there were 12 blank responses, for cluster 68 there were 2 blank responses, and for cluster 34 there were 5 blank responses to Question 9 on education.

TABLE B-7 ALGORITHM FOR DETERMINATION OF AVERAGE LEVEL OF CLUSTER

VARIABLE			
Highest education	Task level index	Number of tasks	AVERAGE LEVEL OF CLUSTER
high	high	high	associate
high	high	low	associate
high	low	high	associate
high	low	low	blurred
low	high	high	blurred
low	high	low	technician
low	low	high	technician
low	low	low	technician

NOTES:

1. For highest education, high indicates over 50% of cluster have completed a certificate course in engineering or higher qualifications. Low indicates 50% or less.

2. For task level index, high indicates an average task level index for the cluster of over 59. Low indicates 59 or less.

3. For number of tasks, high indicates an average number of tasks performed by the cluster of over 50. Low indicates 50 or less.

TABLE B-8 RELATIVE CONTRIBUTION OF EACH AREA OF SPECIALISATION FOR CLUSTERS WITHIN ENGINEERING SYSTEMS AND ADMINISTRATION

CLUSTER NUMBER	TITLE OF CLUSTER	PERCENTAGE CONTRIBUTION TO JOB OF EACH AREA OF SPECIALISATION			
		General G	Mechanical/ manufacturing M	Electrical/ electronic E	Civil Eng./surveying C
230	ENGINEERING OFFICE ADMINISTRATION & DRAFTING	81.8	8.8	4.9	4.4
212	ENGINEERING CONTROL	83.4	6.0	7.8	2.8
173	PRODUCTION CONTROL	55.0	16.6	26.0	2.4
137	ELECTRICAL PLANNING	64.6	2.6	30.7	2.1
269	ESTIMATION & QUALITY CONTROL	85.8	6.6	4.5	3.1
255	ENGINEERING DESIGN DRAFTING	77.3	11.4	5.4	5.9
419	SENIOR ENGINEERING SUPERVISION	85.5	6.4	4.5	3.6
146	MATERIALS TESTERS	83.2	9.4	4.3	3.0
185	CONTROL SYSTEMS	61.4	24.3	10.7	3.6
87	ENGINEERING ADMINISTRATORS	86.0	8.4	4.8	0.8
414	ESTIMATORS	85.6	4.6	4.4	5.4
311	QUALITY CONTROLLERS	86.7	8.2	4.7	0.4
393	DESIGN DRAFTERS	79.4	11.5	3.7	5.3
453	ENGINEERING SAFETY & MAINTENANCE SUPERVISORS	85.2	6.8	5.0	3.0
422	MICRO ELECTRONIC ENGINEERING SUPERVISORS	74.5	2.8	22.3	0.3
347	OTHER ENGINEERING SUPERVISORS	88.7	6.5	4.3	0.5
172	INSPECTORS	80.0	9.4	4.9	5.2
254	ELECTRICAL SUPPLY CONTROLLERS	48.3	8.4	42.2	1.1
571	ENGINEERING ESTIMATORS	83.7	2.9	7.6	5.9
502	MECHANICAL & OTHER DESIGN DRAFTERS	78.8	12.6	3.5	5.1
516	OTHER DESIGN DRAFTERS	82.1	10.6	3.0	4.4
435	Electrical designers	63.0	3.0	33.6	0.4
565	Electrical Contracts Supervisors	66.3	3.8	29.8	0.2
309	Electrical Equipment Drafters	63.7	2.8	32.2	1.3
240	Planners of new electricity supply	69.1	.9	23.2	6.8
521	Building services estimators	86.2	5.3	5.9	2.6
574	Construction Contract Estimators	86.9	5.9	1.7	5.5
671	Electrical Engineering Estimators	77.4	2.2	13.6	6.8
640	Civil Engineering Estimators	90.0	3.5	1.5	5.0
449	Construction Site Supervisors	90.6	5.7	3.6	0.1
444	Quality Control Specialist	93.6	4.8	.9	0.7
457	Quality & Equipment Monitors	86.0	9.1	4.5	0.4
305	Building Services Designers	77.9	11.9	6.7	3.5
448	Construction Design Drafters	80.7	9.2	4.2	5.8
664	Mechanical Design Drafters	72.8	16.2	4.5	6.5
616	Design Drafters (non-computerised)	85.5	7.9	3.4	3.3
657	Design Drafters (computerised)	76.5	15.0	2.3	6.2
299	Senior Hydrology Technical Officers	64.1	8.5	10.6	16.9
469	Civil/Structural Engineering Supervisors	87.3	4.5	1.7	6.6
713	Transport & Civil Engineering Supervisors	82.3	10.8	3.4	3.6
769	General Engineering Supervisors	91.0	4.6	2.2	2.1
652	Engineering Survey/Mapping Supervisors	87.0	2.4	1.2	9.4
609	Electronic Engineering Supervisors	82.3	6.9	9.9	0.9
596	Quality Supervisors	86.9	10.5	0.7	1.9
792	Microelectronic Technician Supervisors	78.9	2.6	18.0	0.6
840	Computer technician Supervisors	67.9	0.6	31.4	0.0
357	Trade Supervisors	91.7	3.6	4.1	0.4
461	Senior Safety Officers	[illegible]	15.2	5.0	0.8
402	Survey Engineering Supervisors	83.1	5.8	0.2	[illegible]
277	Senior Production & Engineering Quality Controllers	82.5	10.4	0.9	6.2
632	Materials Test Technicians/Officers	85.7	9.6	0.1	4.6
703	Materials Test Officers	88.1	7.6	1.7	2.5
349	General Test Technicians/Officers	84.4	7.2	8.4	0.0
182	Site Inspectors/Testers	84.0	3.8	5.4	6.8
232	Inspectors/Recorders	78.4	12.7	4.6	4.3
135	Cartographic Survey Supervisors	80.5	6.6	3.7	9.3
526	Senior Electric Supply Controllers	56.7	6.7	34.9	1.7
548	Electric Supply Controllers	34.4	9.9	54.7	0.9
576	Electro-mechanical Engineering Officers	59.7	21.2	15.8	3.3
493	Mechanical Engineering Officers	68.3	26.8	3.4	1.4
234	Electro-Mechanical Control System Designers	62.2	21.2	11.8	4.8
267	Equipment Evaluation Officers	94.2	1.8	3.5	0.5
259	Production Engineering Officers	83.8	6.2	9.6	0.4
190	Work Study Officers	83.3	11.3	3.0	2.4
238	Aeronautical engineering technicians	81.8	17.8	0.5	0.0

* NOTES:

1. Cluster titles in capital letters are intermediate clusters. Cluster titles in lower case letters are primary clusters.
2. Percentages of over 6% in each of the three specialised areas M, E, and C are underlined. If none of the three specialised areas contribute over 6%, the general area percentage contribution is underlined.
3. The main area(s) of specialistion for each cluster, indicated by the underlined percentage values, are shown in Tables 6.4, 6.5, 6.6 and 6.7.

TABLE B-9 RELATIVE CONTRIBUTION OF EACH AREA OF SPECIALISATION FOR CLUSTERS WITHIN CIVIL ENGINEERING AND SURVEYING

CLUSTER NUMBER	TITLE OF CLUSTER	PERCENTAGE CONTRIBUTION TO JOB OF EACH AREA OF SPECIALISATION			
		General G	Mechanical/ manufacturing M	Electrical/ electronic E	Civil Eng /surveying C
197	CIVIL ENGINEERING	59.2	2.9	1.2	36.8
407	ENGINEERING ASSOCIATE SURVEY DRAFTING	53.9	1.6	0.5	44.0
429	CIVIL ENGINEERING SUPERVISION	66.8	5.2	2.4	25.6
196	CARTOGRAPHIC & SURVEY ANALYSIS	58.9	0.2	3.1	37.9
128	ENGINEERING TECHNICIAN SURVEY DRAFTERS	52.3	0.7	0.1	46.9
198	STRUCTURAL ENGINEERING DESIGN AND DRAFTING	60.7	13.5	0.7	25.1
619	CIVIL DESIGN AND DRAFTING	50.4	1.9	0.2	47.5
560	CIVIL ENGINEERING OFFICE SUPERVISION	62.3	4.3	3.8	29.6
539	CIVIL ENGINEERING SITE SUPERVISION	73.5	6.7	0.2	19.6
249	CARTOGRAPHY	61.0	0.2	1.4	37.4
635	Senior Engineering Survey Drafters	59.3	3.2	1.9	35.6
683	Civil Design and Drafting Officers	50.8	1.8	0.2	47.2
748	Water Storage/Drainage Design & Drafting Officers	47.8	2.0	0.0	50.2
612	Civil Design & Drafting Supervisors	58.8	1.7	0.6	38.9
605	Survey Officers	56.9	0.3	0.9	41.9
674	Civil Engineering Office Supervisors	57.1	4.6	5.7	32.6
693	Senior Civil Engineering Office Supervisors	69.0	4.6	1.3	25.1
763	Civil Engineering Site Supervisors	75.0	6.3	0.1	18.7
704	Civil Engineering Site Officers	71.6	7.2	0.6	20.6
525	Hydrological Analysis Officers	68.9	1.5	2.3	27.3
367	Civil Engineering Officers	70.5	4.6	0.7	24.3
568	Cartographic Survey Drafting Officers	57.7	0.0	0.0	42.3
676	Cartographic Computation Officers	64.3	0.5	2.4	32.9
246	Survey Computation Officers	54.3	0.0	6.7	39.1
445	Structural Designers and Drafters	64.7	13.0	0.4	21.9
471	Civil & Structural Designers & Drafters	46.4	10.3	0.0	42.8
261	Engineering Survey Assistants	69.1	4.3	1.4	25.3
194	Survey Assistants	39.8	0.1	0.1	60.0
488	Road Survey Drafters	63.2	0.0	0.5	36.3
606	Survey Computation & Drafting Technicians	58.0	0.0	0.0	42.0
338	Engineering Survey Drafters	46.4	0.7	0.0	53.0

* NOTES:
1. Cluster titles in capital letters are intermediate clusters. Cluster titles in lower case letters are primary clusters.
2. Percentages of over 6% in each of the three specialised areas M, E, and C are underlined. If none of the three specialised areas contribute over 6%, the general area percentage contribution is underlined.
3. The main area(s) of specialistion for each cluster, indicated by the underlined percentage values, are shown in Tables 6.4, 6.5, 6.6 and 6.7.

TABLE B-10 RELATIVE CONTRIBUTION OF EACH AREA OF SPECIALISATION FOR CLUSTERS WITHIN AND NEAR DRAFTING AND DESIGN

CLUSTER NUMBER	TITLE OF CLUSTER	PERCENTAGE CONTRIBUTION TO JOB OF EACH AREA OF SPECIALISATION			
		General G	Mechanical/ manufacturing M	Electrical/ electronic E	Civil Eng /surveying C
159	DRAFTING	85.1	3.1	2.5	9.3
278	DRAFTING ADMINISTRATION & SURVEY DRAFTING	85.4	1.3	2.3	10.9
324	SURVEY DRAFTING	82.8	1.7	0.1	15.4
301	DESIGN DRAFTING	84.7	6.4	2.2	6.8
242	EQUIPMENT DESIGN	67.8	20.6	5.1	6.5
351	SENIOR SURVEY DRAFTERS	86.0	1.7	0.0	12.3
126	Senior Structural Analysis & Design Officers	63.0	19.2	0.0	17.8
478	Senior Electrical Design Drafters	88.5	0.0	9.8	1.7
513	Senior Electronic Design Drafters	93.4	1.3	3.1	2.3
515	Engineering Survey Drafters	73.9	1.8	0.4	23.9
497	Senior Engineering Survey Drafting Officers	83.6	2.1	0.0	14.4
412	Senior Cartographic Survey Drafters	92.9	0.6	0.0	6.4
542	Building Services Design Drafters	85.7	9.3	4.3	0.8
392	Structural Design Drafters	82.3	7.7	1.6	8.4
389	Other Design Drafters	88.7	0.0	1.0	10.3
285	Mechanical Designers	63.2	23.8	5.8	7.2
406	Design and Development Officers	89.5	5.7	1.6	3.2
134	Civil Design Drafters	72.6	3.4	0.6	23.3
94	Production Method Designers & Planners	78.9	15.1	4.3	1.8
127	Tooling and Equipment Technicians	57.7	35.8	5.4	1.0

* NOTES:

1. Cluster titles in capital letters are intermediate clusters. Cluster titles in lower case letters are primary clusters.
2. Percentages of over 6% in each of the three specialised areas M, E, and C are underlined. If none of the three specialised areas contribute over 6%, the general area percentage contribution is underlined.
3. The main area(s) of specialistion for each cluster, indicated by the underlined percentage values, are shown in Tables 6.4, 6.5, 6.6 and 6.7.

TABLE B-11 RELATIVE CONTRIBUTION OF EACH AREA OF SPECIALISATION FOR CLUSTERS WITHIN AND NEAR ELECTRICAL AND ELECTRONIC ENGINEERING

CLUSTER NUMBER	TITLE OF CLUSTER	PERCENTAGE CONTRIBUTION TO JOB OF EACH AREA OF SPECIALISATION			
		General G	Mechanical/ manufacturing M	Electrical/ electronic E	Civil Eng. /surveying C
89	ELECTRONICS	47.7	4.7	47.3	0.3
67	ELECTRICAL ENGINEERING	45.7	10.0	43.2	1.1
120	ELECTRONIC EQUIPMENT	48.5	5.6	45.4	0.4
115	COMPUTER & DIGITAL EQUIPMENT	46.8	3.1	50.0	0.1
85	ELECTRICAL MONITORING	49.3	13.1	36.5	1.1
56	ELECTRONIC TESTING AND SUPERVISION	74.3	5.1	18.7	1.9
100	EQUIPMENT MONITORING AND CONTROL	51.6	15.0	31.5	1.9
119	Electrical Protection Technicians/ Technical Officers	39.7	5.0	54.4	1.0
175	Electrical Power Generation Supervisors	46.5	10.7	42.6	0.1
207	Automatic Control System Technicians	53.6	5.5	39.6	1.4
183	Equipment Monitors and Maintainers*	50.0	22.9	24.8	2.3
629	Microelectronic Design and Development Officers	48.1	5.7	44.6	1.6
562	Senior Microelectronic Maintenance Technicians	51.8	3.4	44.5	0.3
545	Senior Electronic Maintenance Technicians	54.1	9.5	36.1	0.2
308	Electronic Communication System Repair Officers	39.1	4.7	56.2	0.0
280	Electronic Control System Repair Technicians	29.2	7.4	63.0	0.4
167	Senior Electronic Equipment Officers	65.9	4.8	28.5	0.8
181	Electronic Technicians	59.3	6.1	34.1	0.5
315	Computer and Digital Equipment Installation	50.8	2.5	46.7	0.0
362	Computer and Digital Equipment Maintenance Technicians	39.7	3.4	56.9	0.0
216	Computer and Digital Control Technicians	43.2	4.8	52.0	0.0
229	Biotechnology and other Instrument Technicians	49.7	5.3	44.6	0.5
179	Communication Systems Design and Assembly Technical Officers	46.9	1.2	51.8	0.0
206	Electronic Testers	90.4	4.0	5.5	0.0
92	Electronic Supervisors	69.8	1.5	27.7	0.9
16	EQUIPMENT ASSEMBLY AND REPAIR	55.6	14.8	29.0	0.6
215	Fluidic and Electronic Technicians	77.1	16.1	6.8	0.0
86	Equipment Maintenance Technicians	67.8	25.3	3.8	3.2

* NOTES:

1. Cluster titles in capital letters are intermediate clusters. Cluster titles in lower case letters are primary clusters.
2. Percentages of over 6% in each of the three specialised areas M, E, and C are underlined. If none of the three specialised areas contribute over 6%, the general area percentage contribution is underlined.
3. The main area(s) of specialistion for each cluster, indicated by the underlined percentage values, are shown in Tables 6.4, 6.5, 6.6 and 6.7.

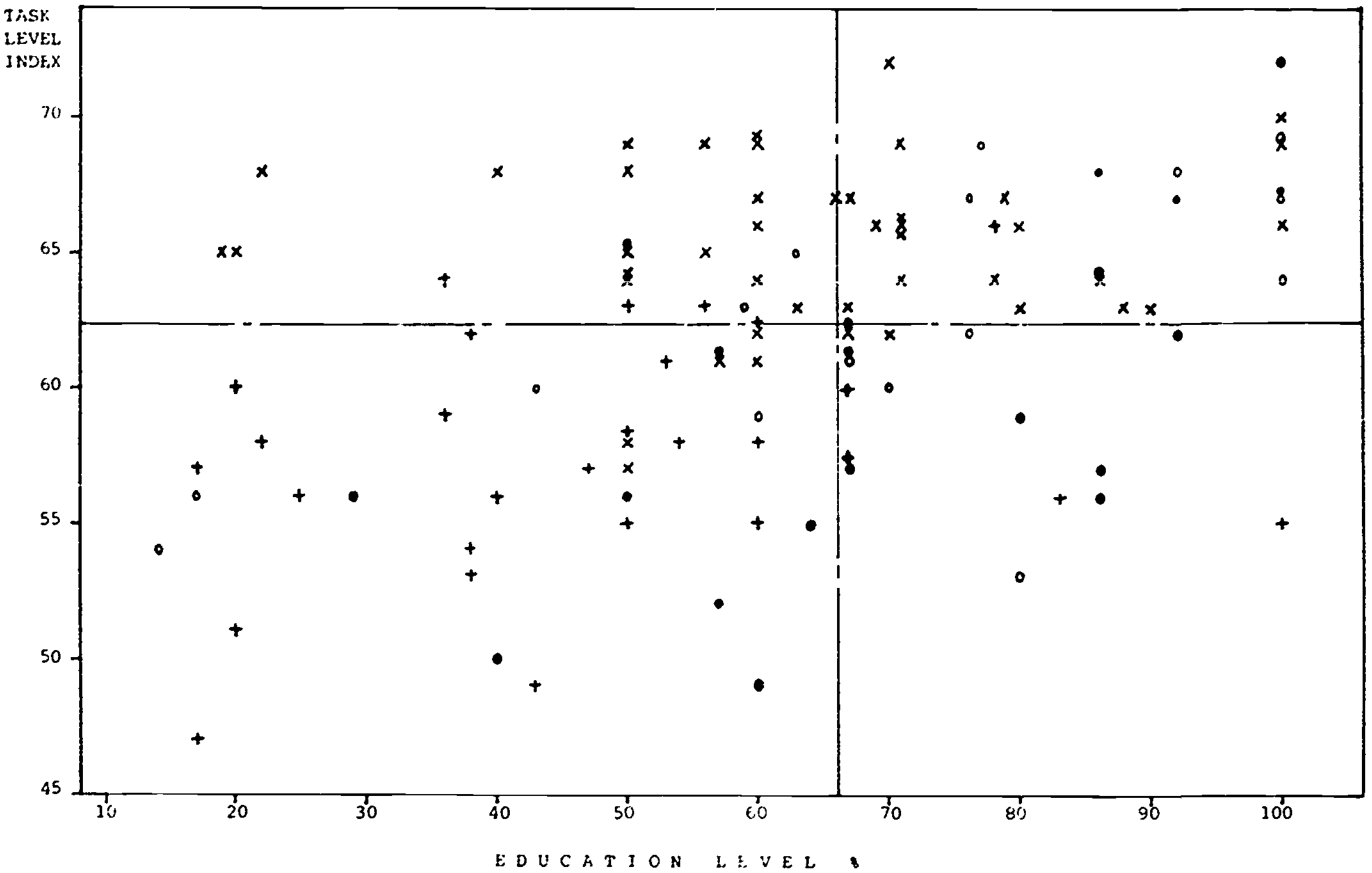

Figure B-1 Scatter plot of the primary clusters on education level and task level index

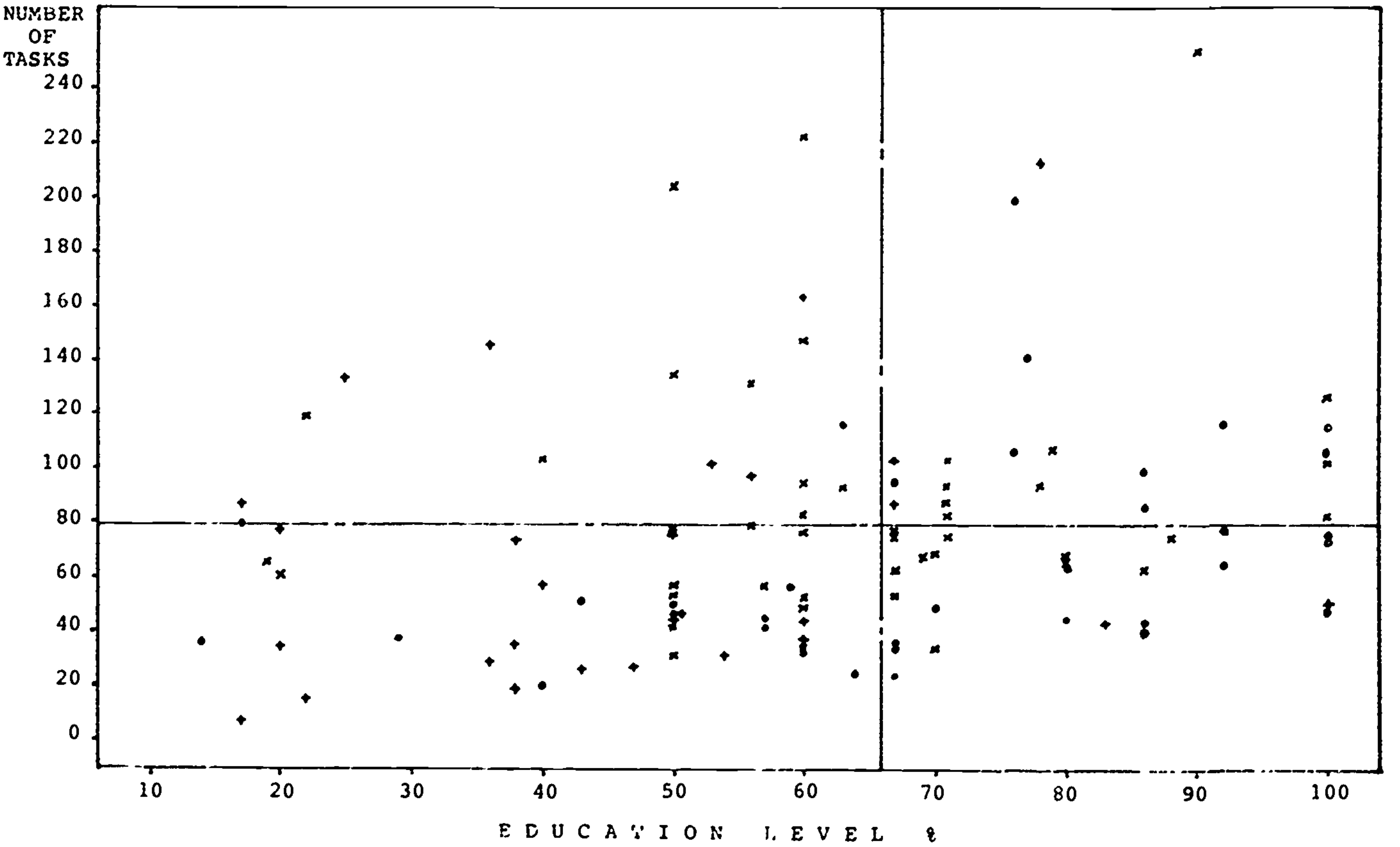

Figure B-2 Scatter plot of the primary clusters on education level and number of tasks

APPENDIX C: TASK LEVEL JOB DESCRIPTION OF THE WHOLE SAMPLE

The following pages contain the task level job description of the whole sample of 1230 respondents. The tasks are in inventory order, as given in the questionnaire. All 61 duties and 621 tasks are listed.

To the right of each task are three items of information. An explanation of each of these follows:

Column 1: Percentage responding - this is the percentage of the sample indicating that they perform the task;

Column 2: Percentage contribution to job for those responding - this is the average percentage contribution to job for those indicating that they perform the task;

Column 3: Percentage contribution to job for all members of sample - this is the average percentage contribution to job, averaged over all members of the cluster. For each sample the sum of the column 3 percentages over all tasks is 100%;

CLUSTER 1 : WHOLE SAMPLE

Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
**** A. PROJECT PLANNING AND MANAGEMENT**			
A1. Prepare construction schedules and bar charts	23.41	.959	.224
A2. Prepare critical path programs	13.64	.714	.098
A3. Maintain records of expenditure on construction projects	21.71	1.111	.241
A4. Monitor progress of work	39.19	1.436	.563
A5. Prepare plant use schedule	13.17	1.070	.141
A6. Supervise site works	33.41	1.376	.460
A7. Co-ordinate progress with other sections	35.37	1.310	.463
A8. Supervise others performing some of the tasks in Project Planning and Management	32.44	1.335	.433
**** B. GENERAL ADMINISTRATION**			
B1. Use standard clerical procedures (eg. keep records or files, fill in forms)	58.21	1.387	.807
B2. Design or develop new clerical procedures	23.33	.716	.167
B3. Review and plan own work	61.22	1.685	1.033
B4. Review and plan the work of a group	42.03	1.440	.605
B5. Record own work (except reports)	52.36	1.366	.715
B6. Arrange visits to other locations	37.69	1.083	.415
B7. Arrange meetings	36.34	.851	.309
B8. Run committees	12.11	.732	.089
B9. File plans and/or documents	54.15	1.166	.632
B10. Search for equipment, materials, drawings or files	64.55	1.299	.838
B11. Photocopy documents	60.41	.980	.592
B12. Print plans	37.54	1.050	.394
B13. Microfilm documents	6.02	.746	.045
B14. Prepare job descriptions and/or duty statements	30.49	1.041	.317
B15. Supervise others performing some of the tasks in General Administration	46.50	1.302	.605
**** C. WRITTEN COMMUNICATION**			
C1. Write letters	60.41	1.328	.802
C2. Write technical notes	58.78	1.336	.785
C3. Write reports	65.28	1.552	1.013
C4. Prepare statistical information	38.46	1.087	.418
C5. Read reports, journals and texts	70.73	1.274	.901
C6. Prepare contract documents	33.17	1.398	.464
C7. Read and evaluate contracts or specifications	45.37	1.279	.580
C8. Read and interpret drawings	78.37	2.145	1.681
C9. Do sketches and drawings	75.61	2.035	1.539
C10. Prepare charts and graphs	48.46	1.126	.546
C11. Supervise others performing some of the tasks in Written Communication	49.02	1.282	.629
**** D. ORAL COMMUNICATION**			
D1. Exchange information with engineers, surveyors or architects	84.63	2.048	1.733
D2. Exchange information with tradesmen	76.59	2.006	1.535
D3. Exchange information with other people within your organisation	86.78	2.322	2.001
D4. Exchange information with clients or members of the public	68.05	1.762	1.199
D5. Participate in meetings	69.11	1.236	.854
D6. Attend lectures, seminars and conferences	60.57	1.067	.646
D7. Give lectures	21.30	.836	.179
D8. Counsel people at work	32.69	1.075	.352
D9. Interview job applicants	24.23	.853	.207
D10. Supervise others performing some of the tasks in Oral Communication	37.64	1.185	.446
**** E. FINANCE AND ESTIMATING**			
E1. Prepare preliminary estimates of costs	47.32	1.455	.689
E2. Prepare detailed estimates of costs	40.33	1.556	.625
E3. Prepare budgets	21.14	1.089	.232
E4. Prepare estimates for staff time	27.80	1.077	.300
E5. Review estimates of cost and/or time	31.14	1.143	.356
E6. Control expenditure	24.23	1.198	.290
E7. Maintain simple accounting	20.41	.985	.201
E8. Supervise others performing some of the tasks in Finance and Estimating	19.19	1.064	.204
**** F. PURCHASING**			
F1. Deal with salespersons	45.77	1.090	.499
F2. Evaluate equipment and machinery	44.31	1.124	.498
F3. Prepare economic appraisal of equipment or machinery	27.24	.832	.227
F4. Examine and select quotes	33.17	1.129	.375
F5. Purchase equipment or services	40.95	1.243	.509
F6. Oversee purchases by staff	18.63	.792	.147
F7. Supervise others performing some of the tasks in Purchasing	18.46	.886	.164
**** G. STAFF DEVELOPMENT**			
G1. Identify staff needs	26.10	.960	.251
G2. Organise staff training programs	17.24	.900	.155
G3. Design and develop training program	13.90	.786	.109
G4. Prepare instructional materials	20.33	.816	.166
G5. Conduct training	24.39	1.020	.249
G6. Manage training and development	13.66	.812	.111
G7. Carry out staff appraisals	22.60	.922	.209
G8. Update own knowledge of latest technology and its applications	48.05	1.439	.691
G9. Encourage other staff to update their knowledge of latest technology and its applications	32.44	1.033	.335
G10. Supervise others performing some of the tasks in Staff Development	14.72	.980	.144

Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
**** H. STAFF SUPERVISION**			
H1. Give direction and supervise tradesmen	46.34	1.609	.746
H2. Give direction and supervise other engineering staff	50.41	1.494	.753
H3. Instruct or direct non-engineering staff (eg, typing, clerical, laboratory staff)	51.06	1.176	.600
H4. Set individual and group goals	32.52	1.167	.379
H5. Assist staff to resolve problems	55.45	1.469	.814
**** J. QUALITY ASSURANCE/QUALITY CONTROL**			
J1. Develop quality policies	14.63	1.067	.156
J2. Plan quality control systems	13.17	1.019	.134
J3. Design quality control procedures	12.76	1.027	.131
J4. Implement quality control procedures	20.57	1.362	.280
J5. Assess quality control procedures	19.11	1.256	.240
J6. Supervise others performing some of the tasks in Quality Assurance/Quality Control	14.47	1.072	.155
**** K. QUALITY TESTING AND MEASURING**			
K1. Design test procedures	16.10	.942	.152
K2. Construct test rigs and instrument packages	14.07	.964	.136
K3. Perform manufactured product tests	14.47	1.336	.193
K4. Perform material tests	14.55	1.598	.232
K5. Perform environmental tests	3.46	.827	[illegible]
K6. Conduct human performance tests	4.23	.552	[illegible]
K7. Use statistical sampling techniques	7.35	1.185	[illegible]
K8. Use control charts	6.91	.957	.066
K9. Specify or use acceptance measurement techniques to verify that products conform to dimensional specifications	14.50	1.465	.217
K10. Calibrate instruments to a standard	17.24	1.499	.257
K11. Program automatic test equipment	6.21	.982	.061
K12. Investigate and rectify causes of poor quality	21.33	1.265	[illegible]
K13. Witness and report on material tests	14.63	1.479	.216
K14. Supervise others performing some of the tasks in Quality Testing and Measuring	15.12	1.085	.164
**** L. MATERIALS TESTING**			
L1. Perform paint tests	2.93	.837	.024
L2. Perform soil tests	6.26	2.417	.151
L3. Perform concrete tests	5.20	1.826	.095
L4. Perform other material tests	11.35	1.513	.171
L5. Supervise others performing some of the tasks in Materials Testing	8.70	1.271	.111
**** M. MAINTENANCE**			
M1. Prepare and cost maintenance and calibration schedules	11.06	.506	.059
M2. Implement maintenance and calibration schedules	19.84	1.332	.264
M3. Evaluate maintenance programs	18.94	1.161	.220
M4. List modes of failure	20.45	1.035	.212
M5. List consequences of failure	[illegible]	1.057	[illegible]
M6. Carry out maintenance inspections	[illegible]	2.153	.765
M7. Monitor the operation of equipment	[illegible]	1.700	.549
M8. Conduct diagnostic testing	[illegible]	1.871	.415
M9. Conduct routine performance tests	27.56	1.683	.464
M10. Supervise others performing some of the tasks in Maintenance	22.85	1.206	.276
**** N. SAFETY**			
N1. Develop and recommend safety programs	14.55	1.067	.155
N2. Monitor safety programs	17.45	1.173	.205
N3. Implement safety programs	25.77	1.442	.372
N4. Administer elementary first-aid	17.24	.931	.155
N5. Supervise others performing some of the tasks in Safety	13.25	1.037	.137
**** P. SITE INSPECTION AND INVESTIGATION**			
P1. Investigate previous engineering work	39.47	1.111	.439
P2. Collect data on location of roads and services through field inspections	29.11	1.281	.373
P3. Inspect land forms on site	22.85	1.096	.251
P4. Collect data on land use	12.44	.754	.094
P5. Inspect developments on flood plains	8.78	.707	.062
P6. Assess extent of river flooding	9.03	.787	.071
P7. Inspect hydrometric monitoring sites	[illegible]	.814	.026
P8. Monitor atmospheric and environmental conditions	[illegible]	.990	.055
P9. Assess foreshore storm damage	[illegible]	.504	.015
P10. Photograph site	25.45	.810	.206
P11. Inspect site for safety and stability during construction	15.85	1.015	[illegible]
P12. Inspect engineering work for compliance with plans and specifications	35.77	1.352	.484
P13. Perform on-site energy audits	[illegible]	.663	.023
P14. Supervise others performing some of the tasks in Site Inspection and Investigation	16.67	.894	.149
**** G. DATA COLLECTION AND ANALYSIS**			
G1. Obtain data from instruments	35.04	1.486	.510
G2. Collect data from engineers and/or clients	35.77	1.278	.457
G3. Tabulate raw data	28.94	1.153	.334
G4. Calculate total, mean, range standard deviation and other simple statistics	19.59	1.002	.196
G5. Use statistical tables and other statistical techniques to analyse and interpret data	19.19	1.021	.195
G6. Disseminate data collected	23.90	1.023	.244
G7. Supervise others performing some of the tasks in Data Collection and Analysis	16.34	.932	.147

Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
** R. USE OF CALCULATORS AND COMPUTERS			
R1. Use calculators	83.46	2.183	1.031
R2. Use programmable calculators	50.57	1.677	.848
R3. Use personal computers/micro-processors	44.31	1.433	.635
R4. Input data or recall data from computer terminals	49.92	1.554	.776
R5. Use mainframe or mini computers through punched cards or terminals	29.84	1.570	.469
R6. Develop computer programs	23.33	.979	.229
R7. Use package programs	42.52	1.430	.608
R8. Modify package programs	13.09	.835	.109
R9. Prepare input for Numerical Control Machines	5.53	1.296	.072
R10. Prepare input for computer assisted drafting (CAD) machines	10.41	1.805	.188
R11. Prepare input for computer assisted machining (CAM) machines	2.28	1.497	.034
R12. Supervise others performing some of the tasks in Use of Calculators and Computers	23.82	1.003	.239
** S. COMPUTER AND DIGITAL EQUIPMENT			
S1. Select digital or computer control equipment	6.42	.586	.038
S2. Assist in conversion of plant requirements to a form acceptable to digital or computer control equipment	7.80	.694	.054
S3. Assist in the design of the program for computer control equipment	6.10	.606	.037
S4. Program computer control equipment	6.42	.760	.049
S5. Become involved with conversion of relay panel functions to digital or computer control equipment	7.24	.736	.053
S6. Explain program of computer control equipment to other persons	8.37	.677	.057
S7. Demonstrate performance of digital or computer control equipment	7.89	.652	.051
S8. Train users of digital or computer control equipment	6.67	.668	.045
S9. Repair and test digital or computer control equipment	9.84	1.339	.132
S10. Modify program of computer control equipment	5.37	.630	.034
S11. Maintain records of digital or computer control equipment	7.89	.852	.067
S12. Supervise others performing some of the tasks in Computer and Digital Control Equipment	6.18	.661	.041
** T. COMPUTING SYSTEMS			
T1. Differentiate between the operating system of different types of hardware	7.07	.681	.048
T2. Operate a multi-user system	9.35	1.111	.104
T3. Analyse and utilise disk and non-disk based micro-computer operating systems	8.21	.932	.077
T4. Evaluate systems on a needs/use basis	5.28	.611	.032
T5. Analyse and utilise minimal and dedicated systems	4.31	.708	.030
T6. Explain the functions of interpreters and compilers to other persons	4.23	.506	.021
T7. Interpret a memory map	4.88	.825	.040
T8. Interface various software with different systems	5.61	.684	.038
T9. Supervise others performing some of the tasks Computing Systems	4.88	.709	.035
** U. DIGITAL AND COMPUTING HARDWARE			
U1. Prepare installation and construction plans and drawings for digital or computing hardware	5.93	.837	.050
U2. Install digital or computing hardware	10.16	1.372	.139
U3. Test new digital or computing hardware	11.14	1.139	.127
U4. Commission new digital or computing equipment	9.84	1.157	.114
U5. Monitor the operation of digital or computing equipment	11.46	1.153	.132
U6. Analyse equipment performance	10.73	1.016	.109
U7. Analyse faults in digital or computing equipment	13.33	1.630	.217
U8. Diagnose and replace faulty components	12.93	1.876	.243
U9. Perform adjustments, clean and lubricate components	12.03	1.643	.198
U10. Determine selection criteria for components	7.07	.960	.068
U11. Evaluate equipment and components	8.94	.785	.070
U12. Recommend the purchase of equipment and components	8.94	.771	.069
U13. Design electronic interface circuitry	8.37	.887	.074
U14. Construct electronic circuitry	10.89	1.177	.128
U15. Test electronic circuits	13.01	1.700	.221
U16. Interface various digital or computing hardware	9.02	1.027	.093
U17. Supervise others performing some of the tasks in Digital and Computing Hardware	2.78	1.020	.090
** V. COMPUTING SOFTWARE			
V1. Develop algorithms for high level language	3.50	.864	.030
V2. Analyse algorithms for high level languages	3.25	.748	.024
V3. Process data (in relatively simple form) in high level language	5.61	.961	.054
V4. Interface and modify high level language programs for operation on different computer types	2.36	.639	.015
V5. Develop algorithms and programs at assembly language level	3.66	.692	.025
V6. Debug algorithms and programs at assembly language level	3.82	.651	.025
V7. Analyse algorithms and programs at assembly language level	3.09	.666	.021
V8. Implement algorithms and programs at assembly language level	3.66	.657	.024
V9. Modify algorithms and programs at assembly language level	3.58	.667	.024
V10. Supervise others performing some of the tasks in Computing Software	2.68	.629	.017

CLUSTER 1 : WHOLE SAMPLE (CONTINUED)

Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
** W. ENGINEERING DRAWING AND GRAPHICS			
W1. Adjust and calibrate conventional drawing machines	20.00	1.212	.242
W2. Adjust and calibrate computer assisted drafting (CAD) machines	3.58	.901	.032
W3. Interpret working drawings	62.28	2.035	1.267
W4. Produce drawings using conventional equipment	51.95	2.337	1.214
W5. Produce drawings using computer assisted drafting (CAD) machines	10.49	1.554	.163
W6. Prepare sketches/artwork	52.76	1.415	.746
W7. Prepare graphs and charts	42.28	1.048	.443
W8. Supervise others performing some of the tasks in Engineering Drawing and Graphics	32.28	1.228	.396
** X. DESIGN DRAFTING			
X1. Prepare a list of the functional requirements of a design proposal	21.06	1.079	.227
X2. Draw flow charts or schematic block diagrams	20.33	.976	.198
X3. Make layout drawings on a computer screen	5.45	.959	.052
X4. Make layout drawings on a drawing board	36.10	2.104	.760
X5. Make assembly drawings	22.85	1.688	.386
X6. Prepare wiring diagrams	17.07	1.224	.209
X7. Make 3-dimensional models	5.12	.593	.030
X8. Make detail drawings of electronic components or circuits that facilitate manufacture or installation	8.78	.958	.084
X9. Make detail drawings of electrical components or circuits that facilitate manufacture or installation	10.65	1.140	.121
X10. Make detail drawings of mechanical components or fixtures that facilitate manufacture or installation	19.51	1.619	.355
X11. Prepare graphics for display or instruction	12.20	.824	.100
X12. Supervise others performing some of the tasks in Design Drafting	19.19	1.156	.222
** Y. ENGINEERING SURVEY DRAFTING			
Y1. Produce survey drawings	21.14	1.490	.315
Y2. Produce site plans	26.18	1.387	.363
Y3. Produce contour plans	22.76	1.284	.292
Y4. Produce profiles	20.65	1.416	.292
Y5. Produce road plans and sections	22.44	1.734	.389
Y6. Produce water, sewerage, drainage and irrigation plans and sections	20.49	1.720	.352
Y7. Supervise others performing some of the tasks in Engineering Survey Drafting	16.26	1.178	.192
** Z. CADASTRAL SURVEY DRAFTING			
Z1. Produce illustrative plans	6.91	1.150	.079
Z2. Produce administrative plans	5.20	1.109	.058
Z3. Produce portion or section plans	5.61	1.348	.076
Z4. Produce deposited plans	3.01	1.323	.040
Z5. Produce strata title plans	2.20	1.285	.028
Z6. Produce plans for annexure	3.17	1.070	.034
Z7. Supervise others performing some of the tasks in Cadastral Survey Drafting	4.15	.981	.041
** AA. ELECTRONIC FABRICATION			
AA1. Fabricate printed wiring boards	8.70	1.163	.101
AA2. Construct mechanical hardware primarily from sheet metals and plastics, employing the skills of reading drawings, bending, drilling, cutting, filling, punching, welding and finishing	10.57	1.282	.135
AA3. Construct electronic hardware, employing the skills of reading circuit and layout diagrams, wire wrapping and high reliability soldering	13.66	1.635	.223
AA4. Comply with workshop, industrial and electrical safety requirements, and perform associated safety checks and tests	12.20	1.385	.169
AA5. Prepare documentation associated with the prototyping of electronic equipment	9.11	1.074	.098
AA6. Supervise others performing some of the tasks in Electronic Fabrication	9.02	.973	.088
** AB. POWER GENERATION, ENERGY TRANSFER AND FLUID FLOW			
AB1. Design select or install equipment related to the switching or conversion of energy to electrical power or fluid power	8.21	1.335	.110
AB2. Design or select pumps, heat exchangers, motors and allied equipment	8.54	1.014	.087
AB3. Monitor the performance of elements of a plan (eg, measure temperatures, pressures)	8.37	1.006	.084
AB4. Maintain equipment related to steam, liquid air or gas flows and power generation	6.99	2.260	.158
AB5. Operate power generation equipment or pumping equipment	6.42	1.653	.106
AB6. Carry out efficiency calculations and energy accounting	5.45	.618	.034
AB7. Follow codes on operating procedures, air pollution or safety	7.48	1.030	.077
AB8. Design or select electricity poles, towers, transformers and cables	5.45	1.106	.060
AB9. Estimate consumer's demand for energy	6.42	.981	.063
AB10. Respond to the impact of the fuel cycle and power generation process on the environment and society	2.93	.664	.019
AB11. Supervise others performing some of the tasks in Power Generation, Energy Transfer and Fluid Flow	5.77	1.342	.077

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Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
** AC. ELECTRICAL POWER GENERATION, TRANSMISSION ** DISTRIBUTION AND UTILIZATION			
AC1. Investigate need for generating plant	4.31	.659	.028
AC2. Assist with environmental impact study for power station or transmission line	1.38	.473	.007
AC3. Assist with preparation of specifications for generating plant	3.74	.773	.029
AC4. Convert manufacturer's drawings to working drawings for tradesmen	3.17	.686	.028
AC5. Operate, under supervision, generating plant	3.58	2.000	.072
AC6. Interpret system alarms	6.83	1.206	.082
AC7. Supervise installation or maintenance of battery systems	5.69	.671	.038
AC8. Supervise installation or maintenance of earthing system	6.10	.672	.041
AC9. Assist with preparation of specifications for transmission systems	2.52	.862	.022
AC10.Prepare switching schedules	3.33	.848	.028
AC11.Perform "live-line working"	2.68	1.071	.029
AC12.Supervise construction of overhead lines or laying of underground cables	3.90	.782	.031
AC13.Commission high voltage overhead lines or underground cable system	2.52	1.126	.028
AC14.Commission medium voltage overhead line or underground cable system	3.74	.966	.036
AC15.Fault-find on high voltage overhead line or underground cable system	3.17	1.253	.040
AC16.Fault-find on medium voltage overhead line or underground cable system	4.23	1.240	.052
AC17.Prepare schemes for new supplies	4.72	1.125	.053
AC18.Arrange for installation of electricity supply and metering	6.10	.952	.058
AC19.Investigate complaints for consumers about electricity supply	3.33	1.049	.035
AC20.Prepare schemes to improve electricity supply	4.55	1.075	.049
AC21.Prepare specification for electrical installation in a building	5.12	1.014	.052
AC22.Assist with design drafting of electrical installation in a building	5.20	1.153	.060
AC23.Select site for electrical equipment	6.42	1.038	.067
AC24.Calculate circuit or system loading	8.54	1.173	.100
AC25.Calculate voltage drop on circuit or system	8.62	1.180	.102
AC26.Calculate fault levels	6.42	.975	.063
AC27.Supervise others performing some of the tasks in Electrical Power Generation, Transmission Distribution and Utilization	6.67	1.050	.070
** AD. AUTOMATIC CONTROL SYSTEMS			
AD1. Investigate need for automatic control systems	7.97	.681	.054
AD2. Prepare specifications for automatic control systems	6.34	.762	.048
AD3. Assist with preparation of specification for automatic control systems	7.32	.640	.047
AD4. Assist with design drafting of automatic control systems	6.83	.847	.058
AD5. Supervise installation of automatic control systems	7.64	.981	.075
AD6. Assist with commissioning of automatic control systems	10.00	.782	.078
AD7. Prepare operation or instruction manuals for automatic control systems	5.85	.544	.032
AD8. Assist with preparation of operation or instruction manuals for automatic control systems	6.67	.586	.039
AD9. Check performance of electrical automatic control systems	10.41	1.030	.107
AD10.Check performance of electronic automatic control systems	10.73	.921	.099
AD11.Check performance of electromechanical automatic control systems	10.08	.846	.085
AD12.Check performance of fluidic automatic control systems	4.23	.898	.038
AD13.Tune the dynamic response characteristics of a control system	3.25	.894	.029
AD14.Maintain automatic control systems	7.48	1.217	.091
AD15.Explain the operation of automatic control systems to other persons	9.59	.678	.065
AD16.Demonstrate the performance of automatic control systems	5.61	.595	.033
AD17.Train operators of automatic control systems	4.07	.526	.021
AD18.Modify automatic control systems	7.15	.782	.056
AD19.Assist with modification of automatic control systems	7.48	.723	.054
AD20.Supervise others performing some of the tasks in Automatic Control Systems	6.42	.711	.046
** AE. EARTH MOVING AND MINING			
AE1. Sell earthmoving equipment	.08	.243	.000
AE2. Design new mechanical equipment or design modifications to existing equipment	3.74	1.417	.053
AE3. Design conveying systems	1.79	1.403	.025
AE4. Interpret geological measurements	1.30	.880	.011
AE5. Make decisions involving selection, care and activation of explosives	1.06	.804	.008
AE6. Maintain drilling, excavating, conveying or pumping equipment	2.68	1.369	.037
AE7. Respond to ecological and social issues relating to the industry	1.30	.994	.013
AE8. Supervise others performing some of the tasks in Earth Moving and Mining	2.44	.945	.023

CLUSTER 1 : WHOLE SAMPLE (CONTINUED)

Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
** AF. MOTORISED TRANSPORT SYSTEMS			
AF1a. Design frames, structures, motor components, drive mechanisms for cars, trucks, agricultural equipment, buses, trains, motorised garden equipment	2.20	2.144	.047
AF1b. Design frames, structures, motor components, drive mechanisms for boats, ships, ferries	1.22	1.413	.017
AF1c. Design frames, structures, motor components, drive mechanisms for aeroplanes, helicopters	.49	1.096	.005
AF2. Test and monitor the performance of land, sea or air vehicles to develop and improve their design	2.36	1.051	.025
AF3. Test land, sea or air vehicles for compliance with regulations	3.33	1.790	.060
AF4. Maintain or supervise maintenance programs on land, sea or air vehicles	5.37	2.437	.131
AF5. Calculate power output, thermal efficiency or fuel efficiency	1.95	1.235	.024
AF6. Sell or order land, sea or air vehicles or components for them.	2.28	1.257	.029
AF7. Construct or supervise or monitor the construction of land, sea or air vehicles	1.30	1.657	.022
AF8. Respond to the social and ecological impacts of land, sea or air vehicles	.98	1.375	.013
AF9. Supervise others performing some of the tasks in Motorised Transport Systems	2.68	1.306	.035
** AG. PROCESS PLANT ENGINEERING			
AG1. Design a plant layout, or modifications to a layout for the continuous production flow of materials and processed goods (eg, foodstuffs, liquids, minerals)	4.55	1.282	.058
AG2. Maintain elements of process plants	3.41	1.152	.039
AG3. Operate and monitor the performance of process plants	2.85	.792	.023
AG4. Order, write specifications for equipment, or sell process equipment	2.68	.875	.023
AG5. Manage hygiene and cleanliness standards	1.71	.781	.013
AG6. Install monitoring and measuring instrumentation	4.39	.965	.042
AG7. Manage liquid and solid waste and gaseous emissions	1.87	1.102	.021
AG8. Select electric motors	5.04	.782	.039
AG9. Work closely with people qualified in electronic and electrical technology	8.37	1.249	.105
AG10. Supervise others performing some of the tasks in Process Plant Engineering	3.50	.869	.030
** AH. METAL FABRICATION, TURNING AND CASTING			
AH1. Design metal frameworks, lifting, carying devices, continuous sheet structures for welding or rivetting operations	8.21	1.704	.140
AH2. Design shafts, axles, or gears to be turned or milled	6.75	1.395	.094
AH3. Design castings and select the casting process	3.58	.973	.035
AH4. Maintain production welding systems	2.68	2.377	.064
AH5. Maintain production machining facilities	2.93	1.957	.057
AH6. Maintain foundry equipment	.81	1.484	.012
AH7. Monitor and maintain safety procedures	3.74	.924	.035
AH8. Design for corrosion resistance	5.69	1.036	.059
AH9. Operate production equipment	2.76	3.796	.132
AH10. Order, purchase or sell production equipment or experimental and test equipment	3.82	.784	.030
AH11. Supervise others performing some of the tasks in Metal Fabrication, Turning and Casting	4.55	2.750	.125
** AJ. WOOD, PAPER, PLASTICS AND PACKAGING			
AJ1. Design packages and containers for function and appearance	1.06	.776	.008
AJ2. Design products to be made of plastic or rubber	2.20	1.121	.025
AJ3. Design dies for injection moulding machines or rubber calenders	.41	.987	.004
AJ4. Maintain moulding machines or calenders	.65	2.580	.017
AJ5. Measure the dimensions of products	1.95	1.341	.026
AJ6. Machine dies or calenders	.41	1.908	.008
AJ7. Design reinforced plastic products	.81	.785	.006
AJ8. Operate moulding equipment	.08	4.225	.003
AJ9. Maintain or select woodworking machinery	1.06	1.299	.014
AJ10. Design products to be made of wood	1.54	.750	.012
AJ11. Supervise others performing some of the tasks in Wood, Paper, Plastics and Packaging	1.38	.896	.012
** AK. BUILDING SERVICES			
AK1. Design air conditioning systems	4.80	2.392	.115
AK2. Design refrigeration systems	2.68	1.325	.036
AK3. Install or maintain air conditioning, refrigeration environment control systems	4.63	1.413	.065
AK4. Design water and drainage services	10.33	1.291	.133
AK5. Perform calculations for pump characteristics, pressure or fire services	5.93	1.191	.071
AK6. Install or maintain wet services	1.71	.698	.012
AK7. Test, research and develop energy systems and materials	1.79	.588	.011
AK8. Monitor and investigate energy consumption	3.25	.557	.018
AK9. Design hoists, lifts and stairways	4.80	.792	.038
AK10. Install or maintain hoists, lifts and stairways	2.20	1.136	.025
AK11. Design security systems - locks, alarms, fire protection and/or systems	5.85	1.129	.066
AK12. Install and test or maintain security and fire protection systems	3.90	1.501	.059
AK13. Supervise others performing some of the tasks in Building Services	7.72	1.115	.086

Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
** AL. ADVISORY AND SPECIALIST SERVICES			
AL1. Assess damage to mechanical systems	11.38	1.401	.160
AL2. Assess damage to electrical systems	10.08	.934	.094
AL3. Assess damage to electronic systems	8.78	.880	.077
AL4. Assess damage to civil engineering works	8.78	.770	.068
AL5. Submit accident reports to insurance companies, courts and companies	6.67	.873	.058
AL6. Assess safety procedures and compliance with safety regulations	10.98	.962	.106
AL7. Make recommendations on the products, policies and services that should be pursued by Government bodies and firms	7.56	.852	.064
AL8. Examine and evaluate patents, product designs and inventions	3.41	.731	.025
AL9. Present seminars, run courses, or teach classes on industrial or technological topics	4.39	.889	.039
AL10. Record atmosphere conditions and monitor operations	2.36	1.031	.024
AL11. Record noise levels	4.47	.722	.032
AL12. Write service bulletins and operating procedures	7.15	.741	.053
AL13. Co-ordinate waste disposal programs or recommend processes	3.01	.734	.022
AL14. Supervise others performing some of the tasks in Advisory and Specialist Services	6.91	.714	.049
** AM. CONSTRUCTION			
AM1. Calculate wind forces, live loads, and static loads on dwellings	7.07	1.015	.072
AM2. Select or calculate section properties of frames	7.24	1.202	.087
AM3. Implement designs using reinforced concrete	9.43	.982	.093
AM4. Design or modify dwellings, bridges, silos, tanks, rigs and platforms	9.67	1.157	.112
AM5. Select processes and products for corrosion prevention	8.62	.850	.073
AM6. Read, follow and apply codes	16.26	1.294	.210
AM7. Hire or sell cranes, construction equipment, or site facilities	3.58	.855	.031
AM8. Supervise erection procedures and demolition procedures	8.46	.978	.083
AM9. Select materials for environmental suitability	8.21	.774	.064
AM10. Monitor and maintain safety procedures	6.67	.933	.062
AM11. Supervise others performing some of the tasks in Construction	8.05	.962	.077
** AN. BIOTECHNOLOGY AND ERGONOMICS			
AN1. Design hand tools	1.63	.843	.014
AN2. Design furniture and fittings for ergonomic efficiency	.89	.637	.006
AN3. Design and develop prostheses	.00	.000	.000
AN4. Design surgical equipment	.00	.000	.000
AN5. Maintain and service medical equipment	.81	3.614	.029
AN6. Maintain and service electro-medical equipment	.65	2.709	.018
AN7. Design and develop surgical aids	.08	.236	.000
AN8. Design and develop ambulatory aids or carrying devices	.41	.422	.002
AN9. Design signs, indicators, alarms, detectors that involve an understanding of human perceptive capacities	1.06	.526	.006
AN10. Monitor atmospheric conditions or operate equipment to maintain environments of desired pressure, humidity, temperature and contamination	1.06	.907	.010
AN11. Dispose of pathological waste products or design containers for transporting biological tissues or cultures	.08	.268	.000
AN12. Supervise others performing some of the tasks in Biotechnology and Ergonomics	.98	.759	.007
** AP. TOOLING AND EQUIPMENT			
AP1. Select suitable equipment and tooling	12.8[illegible]	1.349	.173
AP2. Interpret equipment specification	11.38	1.156	.132
AP3. Investigate need for equipment or tooling	11.63	.998	.116
AP4. Conduct acceptance test on equipment	5.94	.964	.06[illegible]
AP5. Diagnose faults on equipment	13.01	1.384	.180
AP6. Decide on tool material	5.85	1.278	.075
AP7. Select machine settings	5.37	1.723	.092
AP8. Design equipment or tooling	6.34	1.367	.087
AP9. Design modifications to equipment and tooling	8.46	1.089	.092
AP10. Assist with development or manufacture of equipment or tooling	7.48	1.210	.091
AP11. Demonstrate performance of equipment or tooling	5.93	.871	.052
AP12. Supervise others performing some of the tasks in Tooling and Equipment	6.91	.920	.064
** AQ. MATERIALS HANDLING			
AQ1. Select materials handling equipment	6.91	.999	.069
AQ2. Design materials handling equipment	4.88	1.288	.063
AQ3. Select packaging	2.11	.587	.012
AQ4. Supervise warehousing and storage operations	2.68	.875	.023
AQ5. Supervise distribution and transport	2.60	1.435	.037
AQ6. Supervise others performing some of the tasks in Materials Handling	3.25	.655	.021
** AR. PRODUCTION ENGINEERING			
AR1. Plan production	4.07	1.291	.052
AR2. Estimate production rate	4.47	1.158	.052
AR3. Calculate power consumption	1.87	.632	.012
AR4. Plan material routing	2.44	1.099	.027
AR5. Do scheduling or loading	2.52	1.254	.032
AR6. Program inventory control	1.63	.698	.011
AR7. Determine machine loading	2.36	.916	.022
AR8. Determine machine loading	1.87	.838	.016
AR9. Supervise others performing some of the tasks in Production Engineering	2.28	.964	.022

Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
** AS. WORK STUDY			
AS1. Perform method study	4.63	.757	.035
AS2. Perform work measurement	6.50	.858	.056
AS3. Design worker incentive schemes	2.52	.557	.014
AS4. Implement and maintain worker incentive schemes	3.33	.641	.021
AS5. Prepare work performance indices	3.50	.670	.023
AS6. Evaluate project profitability	4.63	1.044	.048
AS7. Determine workplace layout	9.27	.686	.062
AS8. Supervise others performing some of the tasks in Work Study	4.80	.727	.035
** AT. FLUID POWER			
AT1. Design hydraulic circuits	5.20	.902	.047
AT2. Design pneumatic circuits	5.12	1.042	.053
AT3. Design pressure vessels	2.36	.798	.019
AT4. Design fluid values, actuators and/or switches	1.14	.871	.010
AT5. Select fluid power hardware for a given application	6.75	.904	.061
AT6. Install and commission fluid power systems	4.31	1.599	.069
AT7. Daignose faults in fluid power systems	6.50	1.414	.092
AT8. Sell or order fluid power equipment	3.74	.832	.031
AT9. Implement the industrial safety requirements relevant to fluid power systems	2.76	.663	.018
AT10. Supervise others performing some of the tasks in Fluid Power	3.50	.672	.023
** AU. ELECTRICAL INSTRUMENTS AND SENSORS			
AU1. Select instruments for purchase or use	13.33	.850	.113
AU2. Select sensors for automatic control systems	8.21	.755	.062
AU3. Select sensors for computer control equipment	4.80	.605	.029
AU4. Commission sensors	6.67	.770	.051
AU5. Demonstrate performance of sensors	4.39	.478	.021
AU6. Explain operation of sensors or instruments to other persons	10.57	.643	.068
AU7. Calibrate or re-calibrate sensors or instruments	10.81	1.608	.174
AU8. Use instruments and manually control plant	10.33	1.070	.111
AU9. Use instruments when commissioning plant or equipment	13.25	1.192	.158
AU10. Use instruments when fault-finding	21.22	2.024	.430
AU11. Supervise others performing some of the tasks in Electrical Instruments and Sensors	11.14	.973	.108
** AV. POWER ELECTRONIC DEVICES			
AV1. Select thyristors or transisters	8.62	.891	.077
AV2. Select rectifiers	8.29	.870	.072
AV3. Design equipment incorporating power electronic devices	6.50	.603	.039
AV4. Become involved with manufacture of equipment incorporating power electronic devices	6.50	.781	.051
AV5. Become involved with development of equipment incorporating power electronic devices	7.07	.691	.049
AV6. Supervise installation of plant containing power electronic devices	6.59	.726	.048
AV7. Commission or assist with commissioning of power electronic devices	8.70	.847	.074
AV8. Fault-find equipment incorporating power electronic devices	13.01	1.409	.183
AV9. Demonstrate performance of equipment incorporating power electronic devices	6.83	.750	.051
AV10. Operate or use equipment incorporating power electronic devices	11.54	1.122	.129
AV11. Supervise others performing some of the tasks in Power Electronic Devices	9.11	.802	.073
** AW. ELECTRICAL PROTECTION DEVICES, RELAYS AND CONTACTORS			
AW1. Select protection method and device	8.62	.810	.070
AW2. Select relays and contactors	10.24	.890	.091
AW3. Assist with design drafting of protection systems	7.24	.810	.059
AW4. Assist with design drafting of relay and contactor circuits	8.13	.883	.072
AW5. Supervise installation of protection devices	8.21	.759	.062
AW6. Supervise installation of comprehensive protection systems	5.77	.702	.041
AW7. Supervise installation of relays or contactors	8.13	.830	.067
AW8. Commission protection devices	7.97	.937	.075
AW9. Commission or assist with commissioning of comprehensive protection systems	6.75	.749	.051
AW10. Commission relay or contactor circuits	7.80	.990	.077
AW11. Fault-find on relay or contactor circuits	12.68	1.600	.203
AW12. Investigate following the operation of protection devices	10.24	1.114	.114
AW13. Supervise maintenance of relay or contactor circuits	7.24	.855	.062
AW14. Supervise others performing some of the tasks in Electrical Protection Devices, Relays and Contactors	8.86	.845	.075

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Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
** AX. POWER TRANSFORMERS, CIRCUIT BREAKERS AND ISOLATORS			
AX1. Observe and become involved in manufacture of power transformers	.98	.447	.004
AX2. Observe and become involved in manufacture of circuit breakers	.73	.362	.003
AX3. Observe and become involved in development of power transformers	.89	.249	.002
AX5. Investigate need for power transformer	4.15	.766	.032
AX6. Prepare layout plan for substation or distribution board	5.04	.998	.050
AX7. Install power transformer	3.58	1.284	.046
AX8. Supervise installation of power transformer	4.23	.869	.037
AX9. Install circuit breaker	4.55	1.920	.087
AX10. Supervise installation of circuit breaker	4.31	.728	.031
AX11. Commission or assist with commissioning of power transformer	4.47	.704	.031
AX12. Commission or assist with commissioning of circuit breakers	4.96	.717	.036
AX13. Supervise the maintenance of power transformers	3.41	.694	.024
AX14. Supervise the maintenance of circuit breakers	3.50	.710	.025
AX15. Supervise the operating of circuit breakers or isolators	3.90	.810	.032
AX16. Operate, under supervision, circuit breakers or isolators	4.47	1.677	.075
AX17. Supervise others performing some of the tasks in Power Transformers, Circuit Breakers and Isolators	4.80	.792	.038
** AY. ELECTRICAL DRIVES			
AY1. Observe or become involved with manufacture of variable speed drives	2.28	.664	.015
AY2. Observe or become involved with manufacture of fixed speed drives	2.03	.610	.012
AY3. Observe or become involved with research or development of variable speed drives	1.63	.466	.008
AY4. Observe or become involved with research or development of fixed speed drives	1.71	.502	.009
AY5. Assist with preparation of specification for electrical drive	3.74	.615	.023
AY6. Select variable speed drives	5.93	.787	.047
AY7. Select fixed speed drives	7.07	.834	.059
AY8. Supervise installation of variable speed drives	4.80	.498	.024
AY9. Supervise installation of fixed speed drives	5.69	.617	.035
AY10. Commission or assist with commissioning of variable speed drives	5.20	.636	.033
AY11. Commission or assist with commissioning of fixed speed drives	5.77	.607	.035
AY12. Demonstrate the performance of variable speed drives	2.60	.604	.016
AY13. Demonstrate the performance of fixed speed drives	2.60	.478	.012
AY14. Investigate faulty performance of variable speed drives	6.10	1.054	.064
AY15. Investigate faulty performance of fixed speed drives	6.18	.929	.057
AY16. Supervise maintenance of variable speed drives	4.23	.519	.022
AY17. Supervise maintenance of fixed speed drives	4.80	.628	.030
AY18. Supervise others performing some of the tasks in Electrical Drives	4.96	.644	.032
** AZ. ELECTRONIC COMMUNICATIONS			
AZ1. Install, commission and maintain smaller communications systems	8.54	1.966	.168
AZ2. Evaluate the performance of antanae, transmission lines, wave guides or optical fibres	6.42	1.333	.086
AZ3. Install antanea, transmission lines, wave guides or optical fibres	5.93	1.513	.090
AZ4. Design and construct simple circuits, systems and interfaces between incompatible systems	6.18	.950	.059
AZ5. Diagnose and rectify system faults	9.76	1.893	.185
AZ6. Evaluate the suitability of materials, components and equipment/systems for particular applications	6.26	.995	.062
AZ7. Test and evaluate the performance of systems, and recommend and implement changes to improve system performance	7.80	1.092	.085
AZ8. Supervise others performing some of the tasks in Electronic Communications	6.59	1.130	.074
** BA. OTHER ELECTRONIC DEVICES			
BA1. Install an electronic system (ie, radar, sonar, etc)	5.93	1.356	.080
BA2. Commission an electronic system	6.50	1.263	.082
BA3. Overhaul an electronic system	7.15	1.303	.093
BA4. Carry out scheduled maintenance on an electronic system	8.05	1.552	.125
BA5. Carry out performance checks on an electronic system	9.59	1.496	.144
BA6. Carry out manufacturers modific ions, certified modifications, or upd es on electronic equipment	8.70	1.329	.116
BA7. Integrate electronic equipment into a system	7.64	.916	.070
BA8. Supervise others performing some of the tasks in Other Electronic Devices	6.67	1.035	.069
** BB. ENGINEERING SURVEYING			
BB1. Measure distance with tapes	38.94	1.490	.580
BB2. Use the Theodolite in traversing	24.15	1.296	.313
BB3. Use electronic distance measuring devices	11.87	1.330	.158
BB4. Perform levelling by lasers	4.88	.809	.039
BB5. Establish elevations using automatic level	23.33	1.568	.366
BB6. Locate detail using tacheometry	13.82	1.230	.170
BB7. Peg out proposed engineering works	22.44	1.395	.313
BB8. Align machinery	9.11	1.221	.111
BB9. Obtain survey information from surveyor	28.29	1.262	.357
BB10. Supervise others performing any of the tasks in Engineering Surveying	19.35	1.051	.203

Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
** BC. CADASTRAL SURVEYING			
BC1. Define property alignment	8.70	1.247	.109
BC2. Obtain cadastral survey information	9.92	1.238	.123
BC3. Calculate and set out subdivision	4.88	1.247	.061
BC4. Supervise others performing some of the tasks in Cadastral Surveying	4.80	.952	.046
** BD. HYDROGRAPHIC SURVEYING AND DRAWING			
BD1. Perform oceanographic studies, including beach profiles	1.95	.782	.015
BD2. Record location of underwater cable	.33	.385	.001
BD3. Draw and calculate sextant charts	.05	.367	.000
BD4. Plot hand and echo soundings	1.87	.696	.013
BD5. Calculate dredging quantities	1.14	.546	.006
BD6. Plot hydrographic charts	1.54	.707	.011
BD7. Plot channels for harbours and inland rivers	1.30	.841	.011
BD8. Record mooring permits on plans	.00	.000	.000
BD9. Trace flood levels	3.82	.875	.033
BD10. Supervise others performing some of the tasks in Hydrographic Surveying and Drawing	2.03	.701	.014
** BE. SURVEY COMPUTATIONS			
BE1. Calculate reduced levels	28.86	1.554	.448
BE2. Perform geometrical calculations	25.12	1.449	.364
BE3. Adjust linear miscloses in a traverse	16.91	1.108	.187
BE4. Determine co-ordinates	21.30	1.280	.273
BE5. Calculate horizontal vertical curves	19.19	1.354	.260
BE6. Calculate areas and volumes	28.13	1.407	.396
BE7. Supervise others performing some of the tasks in Survey Computations	16.50	1.094	.181
** BF. CIVIL DESIGN AND COMPUTATIONS			
BF1. Perform civil engineering design and/or calculations on water supply and/or reservoirs	8.37	1.130	.095
BF2. Perform civil engineering design and/or calculations on sewerage and/or drainage	18.46	1.340	.247
BF3. Perform civil engineering design and/or calculations on wharf structures and/or foreshore protection	3.01	.636	.019
BF4. Perform civil engineering design and/or calculations on recreation areas and/or landscape design	10.41	.873	.091
BF5. Perform civil engineering design and/or calculations on subdivisions	9.02	1.092	.099
BF6. Perform civil engineering design and/or calculations on footings and/or retaining walls	14.07	.932	.131
BF7. Perform civil engineering design and/or calculations on traffic management	10.24	.885	.091
BF8. Perform civil engineering design and/or calculations on roads and/or freeways	17.97	1.549	.278
BF9. Perform civil engineering design and/or calculations on railways	2.68	.960	.026
BF10. Perform civil engineering design and/or calculations on earthworks	20.57	1.269	.261
BF11. Supervise others performing some of the tasks in Civil Design and Computations	12.93	1.059	.137
** BG. STRUCTURAL DESIGN AND COMPUTATIONS			
BG1. Perform structural engineering design and/or computations on beams, columns, and/or building foundations	13.33	1.473	.196
BG2. Perform structural engineering design and/or computations on buildings	8.54	1.377	.118
BG3. Perform structural engineering design and/or computations on bridges, cranes and/or towers	5.53	1.550	.086
BG4. Perform structural engineering design and/or computations on pre-cast concrete products	4.63	1.239	.057
BG5. Perform structural engineering design and/or computations on hoppers, chutes and/or conveyors	5.61	1.580	.089
BG6. Perform structural engineering design and/or computations on platforms, walkways, stairways and/or ladders	11.14	1.267	.141
BG7. Perform structural engineering design and/or computations on formwork for concrete	4.96	.883	.044
BG8. Supervise others performing some of the tasks in Structural Design and Computations	6.42	1.111	.071
** BH. HYDROLOGY AND HYDRAULICS			
BH1. Perform river gauging	[illegible]	.841	.015
BH2. Perform hydrological analysis and design calculations	6.1[illegible]	1.191	.074
BH3. Determine storm water run off and flood patterns	11.63	1.122	.130
BH4. Determine tidal flushing and ocean dispersal patterns	.89	.414	.004
BH5. Perform hydraulic calculations and design	12.76	1.201	.153
BH6. Calculate pipe diameters to carry design flows	15.45	1.210	.187
BH7. Investigate surcharge	6.34	.954	.061
BH8. Calculate headloss for pipe flow	12.60	1.001	.126
BH9. Supervise others performing some of the tasks in Hydrology and Hydraulics	7.07	.911	.064
** BJ. TOWN PLANNING			
BJ1. Interpret town planning studies and/or town planning legislation	3.33	.736	.025
BJ2. Determine need for a town planning study	.81	.569	.005
BJ3. Design layout of residential area	2.68	.669	.018
BJ4. Do research and make population predictions	.98	.620	.006
BJ5. Perform landscape design	3.58	.587	.025
BJ6. Design recreational areas	3.82	.659	.025
BJ7. Determine road location according to planning and development schemes	4.88	.843	.041
BJ8. Supervise others performing some of the tasks in Town Planning	2.03	.663	.013

Tasks	ALL-RESP Prct Resp	ALL-RESP %Job Resp	ALL-RESP %Job All
** BK. CARTOGRAPHY			
BK1. Compile small scale maps for base plans	10.24	1.067	.109
BK2. Interpret and plot from aerial photographs	9.92	.960	.095
BK3. Prepare grids/graticules for map projections	4.15	.741	.031
BK4. Plot information onto map grids	9.27	1.105	.102
BK5. Perform enlargement and reduction	9.59	1.141	.109
BK6. Chart onto copies of existing maps	8.62	1.110	.096
BK7. Supervise others performing some of the tasks in Cartography	6.34	1.070	.068
** BL. AIR PHOTO AND MAP INTERPRETATION			
BL1. Make use of aerial photos for siting and design of projects	11.30	.769	.087
BL2. Make use of aerial photos for location of catchment boundaries	10.16	.840	.085
BL3. Make use of aerial photos for determination of drainage patterns	10.51	.919	.099
BL4. Make use of aerial photos for land use surveys	7.80	.638	.050
BL5. Make use of aerial photos for data collection	8.05	.931	.075
BL6. Make use of topographic maps for siting and design of projects	12.03	.906	.109
BL7. Make use of topographic maps for location of roads	13.66	.958	.131
BL8. Make use of topographic maps for location of catchment boundaries	11.79	1.045	.123
BL9. Make use of topographic maps for determination of drainage patterns	11.06	.987	.109
BL10. Supervise others performing some of the tasks in Air Photo and Map Interpretation	8.05	.868	.070
** BM. SURVEY INVESTIGATION AND SEARCHING			
BM1. Perform real property search	5.77	.844	.049
BM2. Search survey at lands department	7.48	.881	.066
BM3. Search survey at lands title office	7.32	.847	.062
BM4. Carry out survey investigation	9.35	.908	.085
BM5. Investigate cadastral surveys	5.69	.812	.046
BM6. Define property alignments from existing lands titles, physical occupations and/or previous surveys	8.94	1.125	.101
BM7. Interpret land and survey laws	5.28	.804	.042
BM8. Supervise others performing some of the tasks in Survey Investigation and Searching	5.37	.893	.048
** BN. STILL AND MOVIE PHOTOGRAPHY			
BN1. Use a camera to photograph sites or engineering work	34.55	.928	.321
BN2. Use a video and/or movie camera to record movement at work sites	5.69	.768	.044
BN3. Develop exposed film	2.52	1.115	.028
BN4. Edit video or movie film	2.03	.631	.013
BN5. Supervise others performing some of the tasks in Still and Movie Photography	6.59	.677	.045

APPENDIX D: TASK LEVEL JOB DESCRIPTIONS OF THE FOUR MAJOR CLUSTERS

The following four pages contain the task level job descriptions of the four major clusters. The tasks are in descending order of percentage contribution to job, and only the top 60 tasks (approximately) are given for each cluster.

To the right of each task are five items of information. An explanation of each of these follows:

Column 1: Percentage responding - this is the percentage of the cluster indicating that they perform the task;

Column 2: Percentage contribution to job for those responding - this is the average percentage contribution to job for those indicating that they perform the task;

Column 3: Percentage contribution to job for all members of cluster - this is the average percentage contribution to job, averaged over all members of the cluster. For each cluster the sum of the column 3 percentages over all tasks is 100%;

Column 4: Cummulative percentage - this is the progressive total of the column 3 percentages;

Column 5: Sequence number - this is simply the task sequence number.

CLUSTER 74 : ENGINEERING SYSTEMS AND ADMINISTRATION

	Tasks	Grp 074 Prct Resp	Grp 074 %Job Resp	Grp 074 %Job All ****	Cum <---	Seq
D3.	Exchange information with other people within your organisation	97.72	1.979	1.934	1.03	1
D1.	Exchange information with engineers, surveyors or architects	94.52	1.841	1.740	3.67	2
R1.	Use calculators	93.61	1.632	1.529	5.20	3
C3.	Write reports	91.32	1.664	1.520	6.72	4
D2.	Exchange information with tradesmen	90.19	1.674	1.510	8.23	5
C5.	Read and interpret drawings	86.30	1.735	1.497	9.73	6
D4.	Exchange information with clients or members of the public	84.25	1.686	1.420	11.15	7
B3.	Review and plan own work	81.96	1.625	1.332	12.48	8
C1.	Write letters	89.50	1.474	1.320	13.80	9
D5.	Participate in meetings	93.38	1.334	1.246	15.05	10
C9.	Do sketches and drawings	82.88	1.488	1.233	16.28	11
C2.	Write technical notes	82.88	1.411	1.169	17.45	12
C8.	Read reports, journals and texts	88.81	1.295	1.150	18.60	13
B1.	Use standard clerical procedures (eg, keep records or files, fill in forms)	76.48	1.450	1.109	19.71	14
E1.	Prepare preliminary estimates of costs	67.1.	1.526	1.024	20.73	15
B10.	Search for equipment, materials, drawings or files	77.63	1.290	1.001	21.73	16
H5.	Assist staff to resolve problems	70.78	1.400	.991	22.72	17
A4.	Monitor progress of work	63.47	1.526	.968	23.69	18
C7.	Read and evaluate contracts or specifications	69.86	1.352	.945	24.64	19
E2.	Prepare detailed estimates of costs	58.69	1.608	.943	25.58	20
M3.	Interpret working drawings	63.70	1.476	.940	26.52	21
B4.	Review and plan the work of a group	61.42	1.507	.925	27.45	22
H1.	Give direction and supervise tradesmen	62.37	1.477	.921	28.37	23
H2.	Give direction and supervise other engineering staff	63.93	1.403	.897	29.26	24
C11.	Supervise others performing some of the tasks in Written Communication	65.30	1.335	.872	30.14	25
B5.	Record own work (except reports)	66.89	1.296	.867	31.00	26
B15.	Supervise others performing some of the tasks in General Administration	63.93	1.323	.846	31.85	27
G8.	Update own knowledge of latest technology and its applications	62.79	1.343	.843	32.69	28
H3.	Instruct or direct non-engineering staff (eg, typing, clerical, laboratory staff)	69.18	1.200	.830	33.52	29
A7.	Co-ordinate progress with other sections	59.82	1.370	.820	34.34	30
D6.	Attend lectures, seminars and conferences	82.42	.945	.779	35.12	31
B11.	Photocopy documents	74.20	1.008	.748	35.87	32
B8.	Arrange visits to other locations	63.70	1.170	.745	36.61	33
F2.	Evaluate equipment and machinery	65.07	1.123	.731	37.34	34
B9.	File plans and/or documents	64.84	1.122	.727	38.07	35
A8.	Supervise others performing some of the tasks in Project Planning and Management	52.97	1.340	.710	38.78	36
C4.	Prepare statistical information	58.45	1.184	.692	39.47	37
F1.	Deal with salespersons	65.53	1.031	.675	40.15	38
C10.	Prepare charts and graphs	65.30	1.017	.664	40.81	39
E5.	Review estimates of cost and/or time	52.97	1.224	.648	41.46	40
A6.	Supervise site works	48.40	1.333	.645	42.11	41
F4.	Examine and select quotes	53.88	1.187	.639	42.75	42
H4.	Set individual and group goals	51.14	1.242	.635	43.38	43
D10.	Supervise others performing some of the tasks in Oral Communication	55.02	1.144	.629	44.01	44
F5.	Purchase equipment or services	55.02	1.134	.624	44.64	45
C6.	Prepare contract documents	45.66	1.364	.623	45.26	46
M6.	Prepare sketches/artwork	57.31	1.072	.614	45.87	47
D8.	Counsel people at work	52.28	1.168	.611	46.48	48
R4.	Input data or recall data from computer terminals	47.95	1.257	.603	47.09	49
B14.	Prepare job descriptions and/or duty statements	51.60	1.154	.596	47.68	50
B7.	Arrange meetings	63.24	.927	.586	48.27	51
M4.	Produce drawings using conventional equipment	47.95	1.214	.582	48.85	52
R2.	Use programmable calculators	44.98	1.203	.541	49.39	53
R3.	Use personal computers/micro-processors	43.38	1.219	.529	49.92	54
E4.	Prepare estimates for staff time	46.80	1.116	.523	50.44	55
E6.	Control expenditure	42.92	1.219	.523	50.97	56
N6.	Carry out maintenance inspections	40.18	1.283	.515	51.48	57
P1.	Investigate previous engineering work	43.84	1.140	.500	51.98	58
G9.	Encourage other staff to update their knowledge of latest technology and its applications	48.17	1.036	.499	52.48	59
P12.	Inspect engineering work for compliance with plans and specifications	41.10	1.189	.489	52.97	60
Q2.	Collect data from engineers and/or clients	42.01	1.160	.487	53.46	61
A3.	Maintain records of expenditure on construction projects	38.36	1.211	.464	53.92	62
E3.	Prepare budgets	38.36	1.202	.461	54.38	63
R7.	Use package programs	40.41	1.134	.458	54.84	64
M4.	Make layout drawings on a drawing board	33.79	1.330	.449	55.29	65
G1.	Identify staff needs	42.24	1.031	.436	55.73	66
N3.	Implement safety programs	34.47	1.250	.431	56.16	67
J5.	Assess quality control procedures	31.28	1.371	.429	56.59	68
N7.	Monitor the operation of equipment	37.44	1.135	.425	57.01	69
F3.	Prepare economic appraisal of equipment or machinery	45.43	.907	.412	57.42	70
Q1.	Obtain data from instruments	37.44	1.067	.400	57.82	71
M7.	Prepare graphs and charts	47.26	.844	.399	58.22	72

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CLUSTER 82 : CIVIL ENGINEERING AND SURVEYING

Tasks	Grp 082 Prct Resp	Grp 082 %Job Resp	Grp 082 %Job All	Cum <---	Sec
A1. Use calculators	96.54	1.960	1.892	1.69	1
D1. Exchange information with engineers, surveyors or architects	94.97	1.643	1.560	3.45	2
C2. Read and interpret drawings	89.94	1.726	1.552	5.00	3
C3. Do sketches and drawings	89.94	1.724	1.550	6.55	4
D3. Exchange information with other people within your organisation	92.14	1.651	1.521	8.06	5
W4. Produce drawings using conventional equipment	77.36	1.959	1.510	9.59	6
EE1. Calculate reduced levels	92.45	1.594	1.474	11.06	7
A6. Use programmable calculators	83.33	1.671	1.392	12.46	8
W3. Interpret working drawings	82.70	1.600	1.323	13.78	9
EE1. Measure distance with tapes	85.85	1.515	1.300	15.08	10
EE6. Calculate areas and volumes	88.99	1.425	1.268	16.35	11
Y5. Produce road plans and sections	70.44	1.777	1.252	17.63	12
EF5. Establish elevations using automatic level	72.96	1.667	1.215	18.92	13
EE2. Perform geometrical calculations	80.50	1.471	1.159	20.01	14
D4. Exchange information with clients or members of the public	82.39	1.276	1.051	21.06	15
EE9. Obtain survey information from surveyor	76.73	1.311	1.006	22.06	16
Y2. Produce site plans	72.96	1.366	.997	23.06	17
EE2. Use the Theodolite in traversing	69.50	1.429	.993	24.05	18
Y1. Produce survey drawings	67.61	1.449	.979	25.03	19
Y4. Produce profiles	69.18	1.395	.967	26.00	20
EE5. Calculate horizontal vertical curves	69.81	1.369	.956	26.95	21
EE7. Peg out proposed engineering works	61.95	1.536	.951	27.91	22
EF6. Perform civil engineering design and/or calculations on roads and/or freeways	60.69	1.545	.937	28.84	23
Y3. Produce contour plans	74.21	1.254	.931	29.77	24
B3. Review and plan own work	70.44	1.305	.919	30.69	25
EE4. Determine co-ordinates	70.13	1.294	.908	31.60	26
Y6. Produce water, sewerage, drainage and irrigation plans and sections	62.26	1.454	.906	32.51	27
EF10. Perform civil engineering design and/or calculations on earthworks	68.55	1.304	.895	33.40	28
P2. Collect data on location of roads and services through field inspections	70.44	1.268	.893	34.29	29
A4. Input data or recall data from computer terminals	67.61	1.310	.886	35.16	30
A7. Use package programs	63.52	1.370	.870	36.05	31
EF2. Perform civil engineering design and/or calculations on sewerage and/or drainage	59.75	1.355	.810	36.86	32
E1. Prepare preliminary estimates of costs	63.84	1.253	.800	37.66	33
X4. Make layout drawings on a drawing board	50.94	1.568	.799	38.46	34
W2. Prepare sketches/artwork	65.72	1.212	.797	39.26	35
H2. Give direction and supervise other engineering staff	64.15	1.232	.790	40.05	36
F12. Inspect engineering work for compliance with plans and specifications	59.75	1.300	.776	40.82	37
B10. Search for equipment, materials, drawings or files	76.73	.996	.756	41.59	38
A3. Use personal computers/micro-processors	59.75	1.266	.756	42.34	39
D2. Exchange information with tradesmen	68.24	1.095	.749	43.09	40
P1. Investigate previous engineering work	70.75	.985	.697	43.79	41
E2. Prepare detailed estimates of costs	54.09	1.270	.687	44.48	42
B3. Record own work (except reports)	61.32	1.102	.676	45.15	43
EE3. Adjust linear misclosures in a traverse	60.69	1.105	.671	45.82	44
D5. Participate in meetings	72.01	.930	.670	46.49	45
C1. Write letters	68.87	.971	.668	47.16	46
C3. Write reports	62.89	1.053	.662	47.82	47
P3. Inspect land forms on site	62.26	1.061	.661	48.48	48
C11. Supervise others performing some of the tasks in Written Communication	61.32	1.060	.654	49.14	49
H5. Assist staff to resolve problems	59.12	1.104	.657	49.79	50
C5. Read reports, journals and texts	75.79	.857	.651	50.44	51
EE6. Locate detail using tacheometry	50.00	1.258	.629	51.07	52
B9. File plans and/or documents	69.50	.890	.627	51.69	53
B11. Photocopy documents	75.47	.768	.580	52.27	54
EE10. Supervise others performing any of the tasks in Engineering Surveying	52.52	1.092	.573	52.85	55
EE7. Supervise others performing some of the tasks in Survey Computations	51.57	1.109	.572	53.42	56
C10. Prepare charts and graphs	58.49	.974	.570	53.99	57
F7. Supervise site works	44.65	1.273	.568	54.56	58
EE3. Use electronic distance measuring devices	38.68	1.467	.567	55.12	59
Y7. Supervise others performing some of the tasks in Engineering Survey Drafting	49.06	1.120	.549	55.67	60
C2. Prepare contract documents	49.06	1.116	.549	56.22	61
EH6. Calculate pipe diameters to carry design flows	44.34	1.227	.544	56.76	62
E15. Supervise others performing some of the tasks in General Administration	53.77	1.007	.541	57.31	63
B1. Use standard clerical procedures (eg, keep records or files, fill in forms)	59.43	.908	.540	57.85	64
A5. Use mainframe or mini computers through punched cards or terminals	43.71	1.233	.539	58.38	65
W8. Supervise others performing some of the tasks in Engineering Drawing and Graphics	49.06	1.083	.531	58.92	66
W7. Prepare graphs and charts	58.18	.893	.520	59.44	67
B12. Print plans	63.52	.817	.519	59.95	68

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CLUSTER 68 : DRAFTING AND DESIGN

	Tasks	Grp 068 Prct Resp	Grp 068 %Job Resp	Grp 068 %Job All ****	Cum <---	Seq
W4.	Produce drawings using conventional equipment	92.68	5.201	4.820	4.92	1
C9.	Do sketches and drawings	91.06	5.134	4.675	9.50	2
R1.	Use calculators	99.19	3.816	3.785	13.28	3
C3.	Read and interpret drawings	78.86	4.476	3.530	16.81	4
W3.	Interpret working drawings	86.18	4.049	3.489	20.30	5
X4.	Make layout drawings on a drawing board	78.05	4.445	3.469	23.77	6
D3.	Exchange information with other people within your organisation	84.55	3.772	3.190	26.06	7
D1.	Exchange information with engineers, surveyors or architects	88.62	3.567	3.161	30.12	8
W6.	Prepare sketches/artwork	82.11	2.961	2.432	32.55	9
X10.	Make detail drawings of mechanical components or fixtures that facilitate manufacture or installation	55.28	3.656	2.021	34.57	10
D2.	Exchange information with tradesmen	71.54	2.758	1.973	36.55	11
X5.	Make assembly drawings	53.66	3.603	1.933	38.46	12
B10.	Search for equipment, materials, drawings or files	56.91	2.267	1.290	39.77	13
D4.	Exchange information with clients or members of the public	51.22	2.495	1.278	41.05	14
B12.	Print plans	55.28	2.102	1.162	42.21	15
B9.	File plans and/or documents	52.03	2.164	1.126	43.34	16
W7.	Prepare graphs and charts	55.28	1.916	1.057	44.39	17
W1.	Adjust and calibrate conventional drawing machines	45.53	2.208	1.005	45.40	18
E3.	Review and plan own work	35.77	2.755	.986	46.38	19
C10.	Prepare charts and graphs	42.28	2.243	.948	47.33	20
W8.	Supervise others performing some of the tasks in Engineering Drawing and Graphics	41.46	2.278	.944	48.28	21
R2.	Use programmable calculators	30.08	2.733	.822	49.10	22
B1.	Use standard clerical procedures (eg, keep records or files, fill in forms)	40.65	1.920	.781	49.88	23
B11.	Photocopy documents	47.15	1.571	.741	50.62	24
C11.	Supervise others performing some of the tasks in Written Communication	34.15	2.169	.741	51.36	25
X6.	Prepare wiring diagrams	28.46	2.601	.740	52.10	26
C5.	Read reports, journals and texts	43.09	1.682	.725	52.83	27
D5.	Participate in meetings	47.97	1.503	.721	53.55	28
H5.	Assist staff to resolve problems	33.33	2.089	.696	54.24	29
H2.	Give direction and supervise other engineering staff	32.52	2.083	.677	54.92	30
R4.	Input data or recall data from computer terminals	32.52	2.062	.670	55.59	31
BE1.	Measure distance with tapes	32.52	1.981	.644	56.23	32
H1.	Give direction and supervise tradesmen	28.46	2.164	.616	56.85	33
Y7.	Produce site plans	30.08	2.026	.609	57.46	34
E5.	Record own work (except reports)	31.71	1.917	.608	58.07	35
C4.	Prepare contract documents	20.33	2.925	.595	58.66	36
AK1.	Design air conditioning systems	8.94	6.535	.584	59.25	37
BG1.	Perform structural engineering design and/or computations on beams, columns, and/or building foundations	27.64	2.097	.580	59.83	38
BG6.	Perform structural engineering design and/or computations on platforms, walkways, stairways and/or ladders	22.76	2.533	.577	60.40	39
AH2.	Design shafts, axles, or gears to be turned or milled	23.58	2.437	.575	60.98	40
AH1.	Design metal frameworks, lifting, carrying devices, continuous sheet structures for welding or rivetting operations	18.70	3.068	.574	61.55	41
X2.	Draw flow charts or schematic block diagrams	24.39	2.336	.570	62.12	42
C7.	Read and evaluate contracts or specifications	26.83	2.121	.569	62.69	43
B15.	Supervise others performing some of the tasks in General Administration	28.46	1.944	.557	63.24	44
Q2.	Collect data from engineers and/or clients	22.76	2.369	.539	63.78	45
X12.	Supervise others performing some of the tasks in Design Drafting	28.46	1.895	.539	64.32	46
C2.	Write technical notes	31.71	1.638	.510	64.84	47
X9.	Make detail drawings of electrical components or circuits that facilitate manufacture or installation	21.95	2.272	.499	65.34	48
D10.	Supervise others performing some of the tasks in Oral Communication	22.76	2.190	.498	65.84	49
F1.	Deal with salespersons	30.89	1.610	.497	66.34	50
P12.	Inspect engineering work for compliance with plans and specifications	24.39	2.027	.494	66.83	51
W5.	Produce drawings using computer assisted drafting (CAD) machines	16.26	3.003	.488	67.32	52
H3.	Instruct or direct non-engineering staff (eg, typing, clerical, laboratory staff)	30.08	1.555	.468	67.79	53
X1.	Prepare a list of the functional requirements of a design proposal	23.58	1.976	.466	68.25	54
BG5	Perform structural engineering design and/or computations on hoppers, chutes and/or conveyors	15.45	2.947	.455	68.71	55
Y8.	Produce water, sewerage, drainage and irrigation plans and sections	18.70	2.423	.453	69.16	56
E1.	Prepare preliminary estimates of costs	17.07	2.606	.445	69.61	57
C1.	Write letters	21.14	2.097	.443	70.05	58
R10.	Prepare input for computer assisted drafting (CAD) machines	14.63	2.994	.438	70.49	59

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CLUSTER 34 : ELECTRICAL AND ELECTRONIC ENGINEERING

	Tasks	Grp 034 Prct Resp	Grp 034 %Job Resp	Grp 034 %Job All ****	Cum <---	Seq
D3.	Exchange information with other people within your organisation	92.02	1.680	1.730	1.73	1
U3.	Diagnose and replace faulty components	64.89	2.263	1.465	3.20	2
M1.	Conduct diagnostic testing	74.47	1.940	1.445	4.64	3
M6.	Carry out maintenance inspections	77.13	1.857	1.432	6.08	4
M7	Monitor the operation of equipment	78.72	1.775	1.39[illegible]	7.47	5
M9.	Conduct routine performance tests	74.47	1.838	1.369	8.84	6
D2.	Exchange information with tradesmen	84.57	1.594	1.348	10.19	7
C1.	Read and interpret drawings	78.72	1.701	1.339	11.53	8
U7.	Analyse faults in digital or computing equipment	64.89	1.982	1.286	12.81	9
AC12.	Use instruments when fault-finding	63.83	1.937	1.237	14.05	10
U15.	Test electronic circuits	61.70	1.966	1.213	15.26	11
U9.	Perform adjustments, clean and lubricate components	61.70	1.921	1.185	16.45	12
F1.	Use calculators	86.17	1.190	1.025	17.47	13
D1.	Exchange information with engineers, surveyors or architects	77.13	1.315	1.014	18.49	14
C5.	Read reports, journals and texts	73.94	1.314	.971	19.46	15
F4.	Input data or recall data from computer terminals	58.51	1.480	.870	20.33	16
AA3.	Construct electronic hardware, employing the skills of reading circuit and layout diagrams, wire wrapping and high reliability soldering	56.51	1.476	.864	21.19	17
F3.	Use personal computers/micro-processors	57.98	1.445	.838	22.03	18
D4.	Exchange information with clients or members of the public	51.06	1.592	.813	22.84	19
G1.	Obtain data from instruments	52.13	1.554	.810	23.65	20
AV8.	Fault-find equipment incorporating power electronic devices	51.06	1.567	.800	24.45	21
C4.	Do sketches and drawings	65.96	1.192	.786	25.24	22
C7.	Write reports	65.43	1.169	.765	26.01	23
G5.	Update own knowledge of latest technology and its applications	53.72	1.413	.759	26.76	24
C2.	Write technical notes	65.96	1.147	.757	27.52	25
H5.	Assist staff to resolve problems	53.19	1.398	.744	28.27	26
U14.	Construct electronic circuitry	54.26	1.343	.729	28.99	27
K10.	Calibrate instruments to a standard	41.49	1.746	.724	29.72	28
M4.	List modes of failure	58.51	1.210	.708	30.43	29
B3.	Review and plan own work	50.53	1.399	.707	31.13	30
U2.	Test new digital or computing hardware	51.06	1.382	.706	31.84	31
U1.	Monitor the operation of digital or computing equipment	51.06	1.359	.694	32.53	32
M2.	Implement maintenance and calibration schedules	46.81	1.465	.686	33.22	33
A25.	Diagnose and rectify system faults	38.30	1.787	.684	33.90	34
S9.	Repair and test digital or computer control equipment	45.74	1.491	.682	34.58	35
AW11.	Fault-find on relay or contactor circuits	42.02	1.619	.680	35.27	36
AL9.	Use instruments when commissioning plant or equipment	44.15	1.507	.665	35.93	37
H1.	Give direction and supervise tradesmen	50.53	1.306	.660	36.59	38
G6.	Attend lectures, seminars and conferences	63.30	1.033	.654	37.24	39
F7.	Use package programs	52.66	1.226	.646	37.89	40
M5.	List consequences of failure	52.13	1.224	.639	38.53	41
U2.	Install digital or computing hardware	47.34	1.344	.636	39.16	42
D5.	Participate in meetings	60.11	1.034	.632	39.79	43
BA5.	Carry out performance checks on an electronic system	35.83	1.587	.616	40.40	44
U4.	Commission new digital or computing equipment	44.15	1.393	.615	41.02	45
BA4.	Carry out scheduled maintenance on an electronic system	36.70	1.665	.612	41.63	46
B1.	Use standard clerical procedures (eg, keep records or files, fill in forms)	53.19	1.147	.610	42.24	47
AV10.	Operate or use equipment incorporating power electronic devices	46.28	1.308	.606	42.84	48
B5.	Record own work (except reports)	46.81	1.287	.602	43.45	49
B10.	Search for equipment, materials, drawings or files	56.38	1.063	.599	44.05	50
AF4.	Comply with workshop, industrial and electrical safety requirements, and perform associated safety checks and tests	48.94	1.221	.597	44.64	51
K3.	Perform manufactured product tests	38.30	1.556	.597	45.24	52
U5.	Analyse equipment performance	46.28	1.283	.594	45.83	53
R5.	Use mainframe or mini computers through punched cards or terminals	41.49	1.425	.591	46.43	54
C3.	Interpret working drawings	42.55	1.387	.590	47.02	55
AF5.	Diagnose faults on equipment	38.30	1.441	.552	47.57	56
AJ1.	Install, commission and maintain smaller communications systems	30.85	1.750	.540	48.11	57
K12.	Investigate and rectify causes of poor quality	37.23	1.421	.529	48.64	58
BA6.	Carry out manufacturers modifications, certified modifications, or updates on electronic equipment	36.70	1.414	.519	49.16	59
U16.	Interface various digital or computing hardware	43.09	1.204	.510	49.67	60
R2.	Use programmable calculators	44.68	1.111	.494	50.17	61
M10.	Supervise others performing some of the tasks in Maintenance	41.49	1.182	.491	50.66	62
K2.	Construct test rigs and instrument packages	44.68	1.074	.480	51.14	63